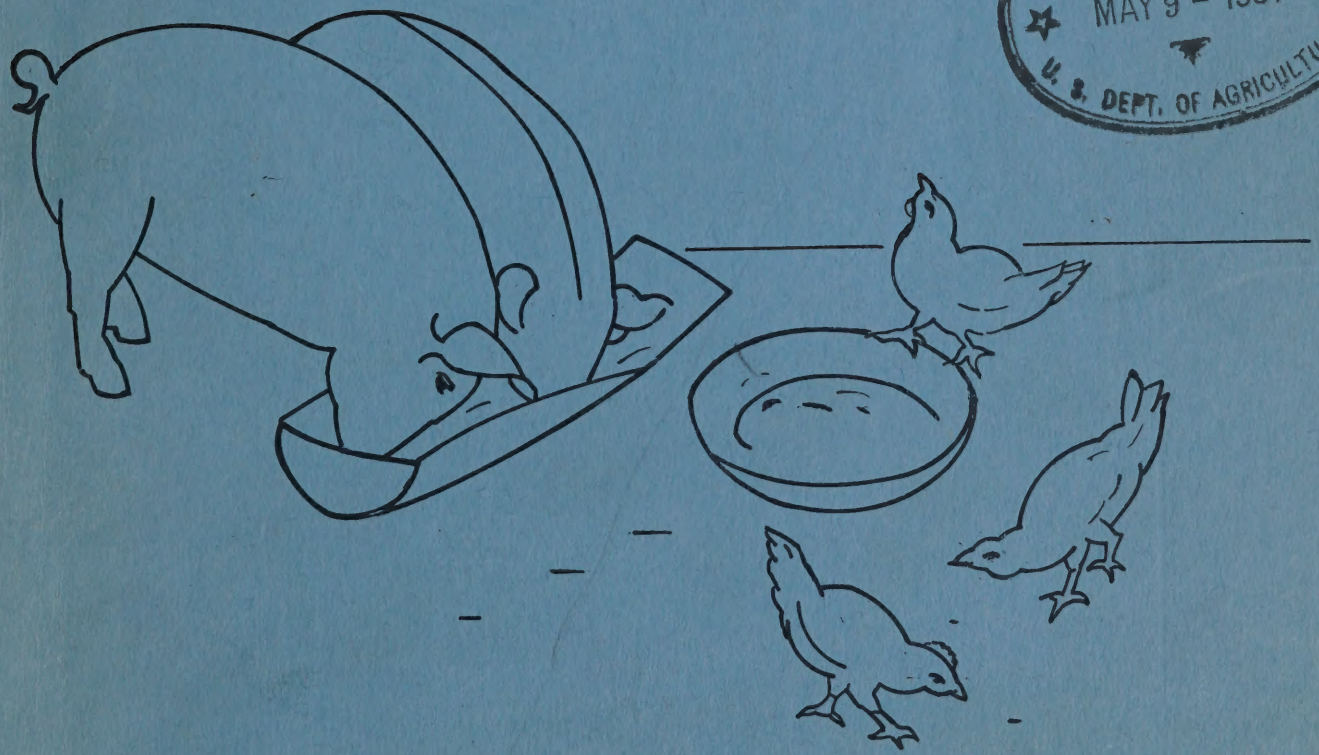
U. S. Department of Agriculture
Agricultural Research Administration
Bureau of Agricultural and Industrial Chemistry

PROCEEDINGS OF A RESEARCH CONFERENCE ON

PROCESSING AS RELATED TO COTTONSEED MEAL NUTRITION

at the

Southern Regional Research Laboratory
New Orleans, Louisiana



November 13-14, 1950

FOREWORD

Fifty-five persons from 20 States and Washington, D.C., representing varied groups interested in cottonseed meal utilization, met with members of the Southern Regional Research Laboratory in New Orleans, La., November 13-14,1950, to mark a milestone of progress and chart a course leading to further improvement.

In particular, they met to evaluate recent cooperative investigations which have shown that screw-pressing conditions can be adjusted to produce cottonseed meal of improved quality and digestibility.

This report records the data presented in papers describing the modified technique and the results obtained on feeding the improved meal.

Further details may be obtained by writing to the Southern Regional Research Laboratory, 2100 Robert E. Lee Boulevard, or to any of the persons listed on the program.

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O P E N I N G R E M A R K S

by
C. H. Fisher, Director
Southern Regional Research Laboratory

and
A. L. Ward, Director, Educational Service
National Cottonseed Products Association

C. H. Fisher

For both the Laboratory and myself, I take great pleasure in welcoming you to this conference on cottonseed meal. We are always glad to have visitors, but we find it particularly pleasing to serve as host to you -- a group of specialists meeting to exchange information and research findings in the important fields of cottonseed meal processing and nutrition.

I think that this is truly an auspicious occasion. We can all look forward to the talks and discussions with the expectation that we are on the threshold of a new era in cottonseed technology and utilization. New information will be exchanged here that might revolutionize the cottonseed industry and increase both the nutritive and monetary value of its products.

The question of the economic and practical value of research is raised frequently these days. I won't attempt now to assess the value of recent research on cottonseed in dollars, but I should like to mention a few of the pertinent economic factors.

Not only is cottonseed the byproduct of cotton -- America's great cash crop -- but it is also one of the principal oilseed crops. In 1949, American farmers received a total of more than 2 billion dollars for cotton lint and 257 million dollars for cottonseed. These are big figures. The stakes are high when we do research to increase the value of cottonseed. For example, an increase in value of only one percent for cottonseed would be worth more than 2.5 million dollars per year.

Modern achievements in research usually have two characteristic features. First, the achievement is made possible by basic knowledge created by fundamental research. Second, the achievement is the result of cooperation and teamwork.

Recent advances in cottonseed meal technology, to be discussed at this conference, are no exception. In a very definite manner, these advances are based on both fundamental research and teamwork.

Much of the basic information on cottonseed was produced in fundamental studies by Dr. Charlotte Beatner and her colleagues working in this Laboratory under the direction of Dr. Klare S. Markley.

These investigators, using the microscope and other tools of fundamental research, developed and published much important basic information on cottonseed, pigment glands, gossypol and related materials. No doubt Dr. Boatner and her coworkers drew heavily upon fundamental data supplied by even earlier investigators. The basic information made available here and elsewhere served as the foundation for the development of practical advances in the technology and utilization of cottonseed meal.

Probably you know very well that teamwork has been a conspicuous feature of the research program on cottonseed meal. The experimental meals were made by the South Texas Cotton Oil Company and others in industry, analyzed by the Southern Regional Research Laboratory, and tested for feeding value by State Experiment Stations and Federal laboratories in Beltsville, Md. The National Cottonseed Products Association has cooperated splendidly and in a most tangible manner. Mr. A. L. Ward, Director of the Educational Service of NCPA, has helped plan and coordinate much of the program. I should like to say that we in the Southern Laboratory appreciate cooperation from other organizations. Cooperation with agriculture and industry is essential if we in the Southern Laboratory are to reach our objective.

In the past, we in the Southern Laboratory have talked most about our applied research and practical achievements. In doing this, I suspect that we have created an erroneous impression about the balance, or ratio, between our fundamental and applied research. In reality, we do much fundamental research in the Southern Laboratory. I believe that we in this Laboratory should talk more about this type of research -- the research upon which our practical achievements are based.

To obtain a better picture of the nature of our fundamental studies on proteins, the most valuable component of cottonseed meal, I asked Dr. Altschul to examine Southern Laboratory publications on proteins and to classify the research described in them as fundamental or applied. He reported that 13 of the 36 papers on proteins are unquestionably fundamental in nature. Some of the papers described applied research, while many of them could not be classified as being distinctly fundamental or applied. I think that we can conclude that at least 50 percent of the work described in these papers was fundamental.

I wish to express gratitude to the several persons who have worked hard and contributed to the success of this conference. In particular, I wish to thank Mr. A. L. Ward of NCPA, and Dr. Altschul, Harry P. Newton and J. A. Kime of this Laboratory. To all of you, I wish to express the wish that your visit will be pleasant and profitable and that you will return at your earliest opportunity. Thank you.

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OPENING REMARKS (continued)

A. L. Ward

This conference is an important occasion for both the cottonseed crushing industry and the livestock industry, especially swine and poultry feeders. Our discussions here today will climax nearly 25 years of cooperative efforts to improve cottonseed meal. The National Cottonseed Products Association has been working actively with the U. S. Department of Agriculture, State Experiment Stations and Land Grant Colleges since 1927, making its information readily available and, on several occasions, supporting fellowships for research. The major objectives of the Association's Educational Service have been:

(1) Cooperation with the U. S. Department of Agriculture to develop scientific facts;

(2) Publication of literature in the language of livestock men; and

(3) Cooperation with the Extension Service in encouraging practical farm practices in feeding cottonseed products to livestock.

The need for knowledge of the effect of processing on the quality of cottonseed meal has long been recognized. Early investigators in Beltsville, Md., in Texas, in Ohio, in Oklahoma, and elsewhere contributed much useful information on both processing and the feeding of cottonseed meal, especially for cattle. Since its establishment in in 1938, the Southern Regional Research Laboratory has obtained much additional data, laying the foundation for unrestricted utilization of cottonseed meal for non-ruminants. The NCPA has actively supported this work.

Furthermore, the combined efforts of the NCPA and the various research agencies have greatly increased research-mindedness in the cottonseed processing industry during recent years. At one time there were over 800 oil mills in the United States. Managers generally left their processing methods up to superintendents who followed old-fashioned techniques handed down by their predecessors. Today, there are fewer mills, but their management believes firmly in science.

The research workers who have developed and tested the new, improved cottonseed meal, to be described here today are to be highly complimented. They have the full support of the National Cottonseed Products Association in this work.

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REVIEW OF NUTRITIONAL RESEARCH ON COTTONSEED MEAL

by

C. M. Lyman
Texas Agricultural Experiment Station

Developments in our knowledge of the nutritional qualities of cottonseed meal may be discussed under three general headings: The nutritive value of cottonseed protein and the effect of processing variables: the presence of material in cottonseed meal which must be removed or modified by processing if unfavorable physiological effects are to be avoided; and the possible presence of unknown nutritional factors in cottonseed meal.

The Nutritive Value of Cottonseed Protein and the Effect of Processing Variables

The nutritive value of the mixed protein of cottonseed meal has been studied in a number of different ways including, nitrogen balance tests as developed by Mitchell and co-worker, feeding trials in which growth rates and efficiency of food utilization are measured, and studies on the amino acid composition and the availability of amino acids. Such investigations all lead to the conclusion that cottonseed protein is of high nutritional value. The biological value of cottonseed meal protein, as determined by the use of rats, ranges from 78 to 81. The value obtained for hogs by Mitchell and Hamilton was 63, indicating a somewhat less efficient use of cottonseed protein by hogs than by rats.

The digestibility of cottonseed meal protein as reported by different workers varies considerably. This variation almost certainly reflects differences in processing conditions.

What can we learn by examining the values for the content of the different essential amino acids in cottonseed meal? The following table shows a comparison of the amino acid content of meat and eggs with corn and cottonseed meal which we feed to the hogs and chickens.

AMINO ACID CONTENT OF SOME FOODS AND FEEDS

Expressed as Percent of Crude Protein

Amino Acid	Whole Eggs	Meat (Pork Loin)	Yellow Corn	Cottonseed Meal
Arginine	6.22	6.41	4.82	10.52
Leucine	8.97	8.62	11.89	6.11
Lysine	7.50	8.69	3.10	4.30
Methionine	3.30	2.44	2.25	1.50
Tryptophane	1.52	1.15	0.84	1.57

Our attention is immediately focused on the discrepancy between the lysine content of the farm feed and the meat and eggs which we expect to produce from it. The situation is not remedied by choosing another grain. This situation emphasizes the importance of carrying out the processing of cottonseed meal so that the maximum percentage of the lysine is available to the animal.

Several years ago, Olcott and Fontaine in agreement with the earlier report by Osborne and Mendel, found that heating cottonseed meal with steam under pressure significantly lowered the overall nutritive value of the protein. This treatment also lowered the solubility of the protein in 3 percent sodium chloride.

It is certainly important to have a fairly simple laboratory test to determine whether the processing of a given sample of cottonseed meal has left the protein in a condition which will promote maximum utilization. Protein solubility has been proposed as such a test.

Ingram, Cravens, and Elvehjem have reported a method for "Evaluating Cottonseed Meal Proteins for Chick Growth by Enzymatic Release of Amino Acids." A series of cottonseed meal samples were fed to chicks and their rate of growth measured. The rate of liberation of amino acids by proteolytic enzymes under controlled conditions was also measured.

A good correlation was found between the results obtained by the in vitro techniques and the growth supported in chicks by the cottonseed meal samples. The method promises to be very useful in future investigations.

The Presence of Material in Cottonseed Meal Which Must be Removed or Modified by Processing if Unfavorable Physiological Effects are to be Avoided.

Limitations on the use of cottonseed meal in rations for farm animals have decreased progressively as the result of continued investigations in this field. To Mr. Hale is due the credit for first showing that cottonseed meal could be used safely in rations for hogs provided the amount was limited to 9 percent of the total ration. This finding has since been confirmed by numerous Experiment Stations. Then we have the early establishment of the fact that gossypol has no unfavorable effect at all on cattle and other ruminants. The problem with respect to the most effective use of cottonseed meal in rations for poultry and hogs has required considerably more attention.

In interpreting the literature on the nutritive value of cottonseed meal, recognition of the wide differences in susceptibility of different kinds of animals to gossypol is quite important. It has already been mentioned that the ruminants are entirely unaffected. At the other extreme we have hogs, guinea pigs, and rabbits. These animals are extremely susceptible. We have an intermediary group which includes chickens and rats. This group is susceptible to gossypol, but only in

relatively large quantities. Feeding trials with rats and chickens showing excellent growth rates and no losses should not be interpreted to mean that the same meal would be suitable for feeding hogs in amounts in excess of 9 percent of the total ration.

It has been well established, for a number of years, that the suitability of cottonseed meal for use in rations for animals other than ruminants is largely dependent on the conditions of processing. Gossypol which is readily extracted from raw cottonseed with ethyl ether is still present in hydraulic or screw press meal where the conditions of processing have been adequately controlled; however, the solubility relationships are changed. The gossypol can be no longer extracted by ethyl ether; its presence can be demonstrated, however, by extraction with aniline with which it combines.

A number of years ago Clark postulated that the change in solubility of gossypol which takes place as a result of a moist heat treatment reflected a combination of gossypol with some of the protein to form an insoluble compound. He called the gossypol, so changed, "combined gossypol." We frequently refer to this form of gossypol as "inactivated gossypol" since its effect, if any, on animals which are susceptible to gossypol is very small.

The development of colorimetric methods for the determination of gossypol supplied much needed tools for investigation on the nutritive value of cottonseed meal, particularly as affected by processing. The first of the colorimetric procedures was developed at the Texas Agricultural Experiment Station. The method was based on the color produced by adding aniline to extracts containing gossypol. Since that time a number of new and improved methods have been introduced including two from the Southern Regional Laboratory here.

In 1944, the group at Texas A & M reported a method for controlling the processing variables in the hydraulic procedure in order to make meal very low in free gossypol. The results of feeding meal processed under a variety of different conditions brought out the relationship between moisture, temperature, and time of processing to the free gossypol content of cottonseed meal.

Some further comments concerning the term free gossypol may be in order. It would certainly be convenient for the research worker if the dividing line between free and bound gossypol were sharp and well defined. Such is, unfortunately, not the case. The firmness of binding of gossypol with other constituents appears to vary continuously from the free gossypol to a fraction which cannot be removed with the most exhaustive extraction. This points to a need for standardizing conditions for the determination of free gossypol.

During recent years it has been seriously questioned whether gossypol is the toxic principle of cottonseed. Experimental findings have certainly justified this questioning; for example, in an investigation by Boatner and co-workers, pure gossypol was fed to chicks. As a result, there was little retardation in the growth rate; whereas feeding

cottonseed pigment glands, or uncooked hexane-extracted cottonseed, resulted in marked depression in growth rates. Experiments in our own laboratory indicated that feeding pure gossypol to guinea pigs had much less effect than feeding cottonseed meal containing an equivalent amount of free gossypol. However, gossypol in sufficiently large quantities was toxic.

On the other side of the picture, Lillie and Bird found that pure gossypol and pigment glands containing an equivalent amount of gossypol had the same effect on chicks when the gossypol was fed in capsule form.

The recent paper by Castillon and Altschul on the "Preparation of Water-Soluble Combination Products of Gossypol and Their Toxicity to Aquarium Fish" is of particular significance in connection with this problem. Gossypol-protein, gossypol-starch, gossypol-dextrose, gossypol-glycine, and gossypol-lysine were prepared. The toxicity of the complex materials varied over a wide range. The reactivity of gossypol with such a wide variety of substances and the resulting change in toxicity make it unnecessary to postulate the existence in cottonseed of any other substance with toxic properties.

Several different manufacturing procedures which result in unquestionably superior cottonseed meals from the nutritive standpoint have been worked out. Among them may be mentioned the gland-free meal prepared here at the Southern Regional Laboratory and the solvent-extracted meals made by solvents such as isopropyl alcohol, which reduce the free gossypol to a very low level. Production costs will determine whether these methods are commercially valuable.

The principle of reducing free gossypol by controlling the shearing action of the screw press appears to offer great possibilities. We shall hear more about this during the present meeting.

The Possible Presence of Unknown Nutritional Factors in Cottonseed Meal

In 1948, Zucker and Zucker reported the results of an investigation of "Lactation in Rats on Well-Fortified All-Plant Rations." When soybean meal was used as the protein supplement, lactation failed. When the soybean meal was replaced with cottonseed meal, normal lactation resulted, thus indicating the presence of an unknown nutritional factor necessary for normal lactation. It should be kept in mind that vitamin B_{12} was not included in these experimental rations.

Another very interesting report appeared in 1949. Ruegamer presented evidence of an unidentified rat growth factor in cottonseed meal. Here again, all-vegetable rations were used. The type of assay was essentially the same as that used for the determination of vitamin B_{12}. The addition of desiccated thyroid to a ration in which soybean oil meal supplied the protein resulted in marked depression of growth or even loss of weight of the animals. In Ruegamer's experiment when cottonseed meal was substituted for the soybean oil

meal the marked depression in growth rate did not take place when the desiccated thyroid was fed. The addition of liver preparations containing vitamin B_{12} resulted in normal growth with soybean oil rations. At that time it could not be determined whether the results of these experiments were due to the presence of vitamin B_{12} in cottonseed meal or to some other substance.

With reference to the possibility that cottonseed meal contains vitamin B_{12}, we may refer to the publication by Richardson and Blaylock who showed that rations containing as much as 30 percent cottonseed meal still responded to the addition of preprations of vitamin B_{12}. It may be mentioned that in these experiments the vitamin B_{12} preparations did not contain any antibiotics.

We may now refer to the work of Millikan and Bird who studied the effect of cottonseed meal processing variance on chick growth. These experiments under the conditions used failed to show any evidence for an unknown growth factor.

It seems clear now that cottonseed meal is not a source of vitamin B_{12}. A number of recent papers have dealt with the complicated interrelationships of the metabolism of methionine, homocysteine, choline, and betaine with vitamin B_{12}. It is known that the requirements for vitamin B_{12} are modified by the level of some of these substances in the ration. The possibility of the presence of some substance in cottonseed meal which exerts a sparing action on vitamin B_{12} is suggested here.

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REVIEW OF METHODS OF ANALYSIS OF COTTONSEED MEALS

by

T. H. Hopper
Southern Regional Research Laboratory

Analysis of feeds to estimate their nutritive value has been the subject of much study during the last 150 years. During this period much has been learned of the composition of feeds and the nutritive requirements of animals. Feeding standards have been developed and widely used. These developments have contributed immensely to the economy and expansion of the livestock industry and to the commercial evaluation of feeds for trading purposes. Yet, in the final analysis of the nutritive value of feeds, it is necessary to depend on the growth and fattening response of experimental animals. Many of the qualitative characteristics of feeds, when fed alone and in combinations, have not been explored sufficiently to allow basing evaluation of nutritive value on analytical results alone.

The present discussion will be limited to consideration of some aspects of the laboratory estimation of protein quality and of the determination of gossypol pigments in connection with the work of this Laboratory on increasing the utility and nutritive value of cottonseed meal.

The Analysis of Protein

The protein content of a feed is customarily estimated by multiplying the nitrogen content by a factor (6.25). This gives a quantitative value but tells nothing of the qualitative characteristics and of what biological value the protein may have as a nutrient. Proteins differ in their amino acid contents and are modified physically, and perhaps chemically, in oilseed meals by the processing methods by which they are obtained from the seeds. Ultimate evaluation of the nutritive value of a protein appears to depend on development of ready means of knowing the digestibility and the biological value of the digested portion taken into the blood stream.

Nitrogen solubility has been given considerable attention as an approach to the laboratory bench estimation of the quality of protein. In the processing of cottonseed, conditions are established which contribute to the heat denaturation of the protein in the resulting meal. When exposed to denaturing agents, proteins undergo a number of changes which are: (1) decreased solubility; (2) increased digestibility by proteolytic enzymes; (3) exposure of oxidizing and reducing groups (4) loss of enzymatic properties if the protein is an enzyme; (5) modification of the specific immunological properties; and (6) decreased diffusion and increased intrinsic viscosity of the protein.

To certain extents, this heat denaturation is influenced by moisture. It starts at a temperature of approximately 60° C. In addition to denaturation, excessive heat may cause some degradation or destruction of protein which is expected to reduce its nutritive value.

The decrease in protein "solubility" has been evaluated through determination of the nitrogen peptized under conditions of the test expressed as a percentage of the total nitrogen in the sample. The results are used as a means of indicating the effect of heat during the processing of the seed on the properties of the protein.

Two methods have been used in this Laboratory for peptizing the protein of cottonseed meals. One specifies the use of an 0.5 N water solution of sodium chloride. The other specifies peptizing in water with the pH adjusted to a specified value with sodium hydroxide. The soluble nitrogen is taken as that present in the supernatant.

It seems that the peptizability of the proteins differs and that methods found useful for one protein do not apply equally well to others. In this connection the general use of water alone for peptizing soybean protein in determining the soluble nitrogen is cited.

The values obtained for soluble nitrogen are considered empirical. The soluble nitrogen as a percentage of the total nitrogen varies with the choice of methods, and consequently varies with ratio of sample to dispersion media; time, temperature, and agitation of dispersion; amount and method of removal of lipids; fineness of grinding of sample; and the nature of the dispersion media.

Another approach to estimation of the influence of conditions of processing cottonseed on the quality of the protein in the meal now being examined is through the determination of thiamin . It was suggested to us by J. W. Hayward of Archer-Daniels-Midland Company, who had observed that the destruction of thiamin in soybeans parallels the loss in nutritive value of the protein attributed to the action of heat during processing.

The method used is based on the work of Conner and Straub and involves the oxidation of thiamin to thiochrome which fluoresces in ultraviolet light. This method is essentially the same as the one recommended by The Association of Vitamin Chemists.

Determination of Gossypol

In extending the utility of cottonseed meal as a feed, especially for swine and poultry, gossypol pigments are still a problem. Gossypol is a polyphenolic compound present in the pigment glands of cottonseed. On processing the seed by the present hydraulic- and screw-press methods, the glands are broken and the gossypol mixed with the substances of the seed. According to present evidence, the gossypol reacts with the free amino and carboxyl groups of the protein and is "bound." However, this reaction, controlled by time and temperature, is not complete and some of the gossypol is not "bound" in the finished meal. Thus, there is always some free gossypol, in addition to the bound gossypol, in all commercially processed cottonseed meals.

Cottonseed also contain pigments related to gossypol. These pigments include gossypurpurin, gossycaerulin, and gossyfulvin, which have been characterized. Those wishing detailed information on the pigments of cottonseed are referred to Dr. Boatner's chapter on the subject in the monograph on "Cottonseed and Cottonseed Products," edited by A. E. Bailey.

The methods used currently here are based on the principles of the one developed by F. H. Smith, which involved the reaction of extracted gossypol with aniline to produce a colored reaction product,

suitable for colorimetric estimation. p-Anisidine, a colorless crystalline compound, is used in place of aniline.

For the determination of free gossypol pigments in cottonseed materials, the extraction is made with aqueous acetone in which the pigments are sufficiently stable for the purposes of the method. In determining total gossypol, the hydrolysis of the bound gossypol pigments in cottonseed meals is accomplished in a solution of oxalic acid in aqueous ethyl methyl ketone. In analyzing oils for gossypol pigments, the sample is dissolved in a mixture of hexane and isopropanol.

These methods for gossypol pigments are suitable for routine analysis of cottonseed products. To the best of our knowledge, they determine the total of the free or free and bound pigments, as the case may be, and do not distinguish between gossypol and the several related gossypol pigments that are, or may be, present.

The value of the results obtained by use of these methods of analysis will be cited later on this program by F. H. Thurber in his report on the "Effect of Processing Conditions on Chemical Properties of Cottonseed Meal."

It is suggested that those interested in the details of the procedures used discuss them informally with Mr. C. L. Hoffpauir and Mr. R. T. O'Connor, Acting in Charge of the Analytical and Physics Sections, respectively. It would seem unnecessary to go into the details of the techniques at this time.

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THE PIGMENT GLAND-FRACTIONATION PROCESS

by

E. A. Gastrock
Southern Regional Research Laboratory

If we were seeking a single reason to justify this meeting, that reason might be compressed into one word -- gossypol. This unique compound and its related forms are found within discrete sacs, called pigment glands, embedded in the meal tissue of the cottonseed. The pigment gland content of cottonseed meats ranges from 1 to 4 percent, and the gossypol content of the pigment glands varies from 39 to 49 percent.

It is hardly necessary for me to tell this audience why gossypol and pigment glands are important in cottonseed processing. Cottonseed meal is used almost entirely as feed for animals. While its use for

ruminants is generally not restricted, there are definite limitations at present on its use for swine and poultry. These restrictions are due mostly to the gossypol content of the meal — principally the free gossypol content.

It was natural, then, for workers at the Southern Regional Research Laboratory to spend a great deal of effort on the study of gossypol and its related compounds, and on the glands which contain these pigments.

The Flotation Method

In some of the early work of Dr. Boatner and her associates it was observed that, if cottonseed meats or flakes were disintegrated in a Waring blendor in the presence of a liquid which was inert toward the various components involved, some of the pigment glands were freed from the surrounding tissue. Suitable liquids were a number of petroleum hydrocarbons, some chlorinated solvents and cottonseed oil itself. In general, a solvent that mixes with water, and water itself, are not suitable due to the rupturing effect on the pigment glands.

A further observation of these workers was that the various solid components of the meats had differing densities and that a mixture of chlorinated and non-chlorinated solvents could be made that would have a density between that of the pigment glands and that of the meal, permitting the glands to float and the meal to sink. Hull particles, if present, would sink with the meal, from which they could be separated later by using a solvent mixture of slightly higher density than that used before. The hulls are denser than the meal and would then sink while the meal would float.

This method, called flotation, was expanded to a larger scale and used in the production of about 100 pounds of pigment glands and about 1,000 pounds of purified meal. These materials were used in a great many evaluation tests to establish the outstanding properties of the purified meal, and in additional research on pigment glands and gossypol.

Attention was then directed to further development of the flotation method in order to determine its commercial possibilities. Differences in density between the pigment glands and meal portions of cottonseed, although definite, are small, so that when flotation is practiced batch-wise in a tank the separation requires a long period. It was natural, then, that continuous methods using centrifugal equipment should be tried. However, these machines produced an unexpected result. The fine material which settled under quiescent conditions in a mixture of solvent having a density of 1.376 would not respond to the gravity differences in a continuous centrifugal machine. The fine meal material would be discharged in the overflow with the pigment glands rather than in the underflow with the hulls and coarser meal particles.

Differential Settling

This forced a revision of the process. Now, by using a single solvent, hexane, and by applying the principle which we term differential settling, we can remove the fine purified meal particles as a suspension after the rest of the material has settled. This procedure was found to work satisfactorily — batch-wise in tanks or in continuous machines.

The overall process, however, is not as simple as that. The cottonseed meats in flake form, suspended in commercial hexane, must be carefully disintegrated to separate the fine meal from the pigment glands: and the pigment glands must remain essentially undamaged in the disintegration operation. Any appreciable damage to the pigment glands results in some gossypol leaving the glands and combining with the meal to a variable extent. This we must avoid.

It is important to remove material from the disintegrating zone as quickly as the pigment glands are released and fine material, free of glands, is produced. A good way to do this is to pass the material in slurry form over screens having openings of different sizes. On a 14-mesh screen, coarse hull particles, rather free of meal, can be removed. The material retained on a 60-mesh screen is returned for further disintegration. Material sufficiently disintegrated passes through the 60-mesh screen and is ready for the differential settling step.

Differential settling of the through 60-mesh fraction separates the purified fine meal tissue from the released pigment glands. The solvent is then removed from the purified fine meal by centrifugation or filtration, followed by a drying step.

Fractionation may be carried out as an independent process following hulling of the seed, or it may be carried out after a partial defatting in conventional solvent extraction equipment.

It is not possible in the scope of this talk to discuss at any considerable length the problems which remain to be solved. They are not simple, and they involve processing operations many of which have no industrial counterpart. Our present emphasis in the work is to produce several tons of purified meal, and in order to do this we have had to place a second priority on process development.

The Products of Fractionation

I would like to devote the rest of the time available to a discussion of the products of fractionation. Oil produced by fractionation should be equal in quality to that produced by solvent-extraction using commercial hexane.

The purified meal produced, however, is unlike any cottonseed meal now offered for sale. It is light yellow to creamy-white in color and is produced as a fine flour. We believe it could be produced in a form similar to pearl starch. It is practically free of hulls and has a free gossypol content of about .06 percent. The nitrogen content is about 10 percent, corresponding to a protein content of about 62.5 percent. The protein solubility in 0.5 N NaCl is the highest of any cottonseed meal we know -- about 85 percent. Similarly, its thiamin content, 39 parts per million, is the highest of any cottonseed meal that has been studied to date.

There is evidence that the loss of essential amino acids in fractionated cottonseed meal, due to processing, is less than for other cottonseed meals, and also that the essential amino acids present have greater availability for nutritive purposes. In other words, the protein of fractionated cottonseed meal is just about as close as we have been able to get, on any appreciable scale, to the native protein in cottonseed.

The pigment glands are obtained as a concentrated fraction. Further processing can be applied to yield fairly pure pigment glands or the gossypol can be removed with solvents from this concentrated material. Gossypol should be an interesting chemical raw material. The gossypol content of an annual crop of cottonseed is about 50,000 tons, and if quantity uses can be developed for the pigment we believe it can be produced at a reasonable price. I am sure the cottonseed processing industry would not object to an additional source of revenue from gossypol, at the same time it is making a most nutritious meal and a high grade oil.

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EFFECT OF PROCESSING CONDITIONS ON CHEMICAL PROPERTIES OF COTTONSEED MEAL

by

F. H. Thurber
Southern Regional Research Laboratory

About three years ago, studies were begun at the Southern Regional Research Laboratory to compare the chemical properties and nutritive values of commercially processed and experimentally processed cottonseed meals. The variations in these values were so unusual that the results were reported to a committee of the Agricultural Research Administration of the U. S. Department of Agriculture in Washington. The Committee decided that a re-examination of the relationship between the nutritive value and methods of processing should be made. The research program begun at that time has led to the production of the highly nutritive cottonseed meals being considered at this meeting.

Commercial cottonseed oil mills, State Experiment Stations, and the Beltsville Station have cooperated with the Southern Regional Laboratory in this research program. Inasmuch as it is desirable to have the results of nutritional investigations directly applicable to industrial practice, experimentation on processing conditions has been done in industrial plants insofar as possible. Solvent-extraction, hydraulic-press, and screw-press procedures are all being investigated; but due to the interesting developments in screw-press meals these are being given immediate attention.

In cooperation with the Southern Regional Laboratory, four different series of meals have been prepared by the South Texas Cotton Oil Company under carefully controlled processing conditions at their Harlingen, Texas, plant. Temperature, time of cooking, moisture content in the cooker, press throughput, and energy input to the screw press, were varied over wide ranges. Differences in chemical properties were determined by the Southern Regional Laboratory and meals were then submitted to State and Federal Experiment Stations for nutritional investigations with rats, chickens, swine, and dairy cattle. Progress reports on these nutritional investigations are being made at this meeting by other speakers.

Processing conditions and chemical properties of typical meals prepared for these investigations are shown in the table on page 19.

Processing Conditions

In preparing these screw-press meals a 4-ring cooker was used and the temperature was gradually increased from the first to the fourth ring. For example, in run S5-1 the temperature recorded in each of the 4 rings were 130, 194, 222, and 230° F.; consequently, the meats were not cooked at the maximum temperature for the maximum time indicated in the table. Maximum cooking temperatures were varied from 160° F. to 280° F.; time in the cooker from 20 min. to 100 min.; throughput in the press from 46 to 62 pounds in 5 minutes, and energy input to the press from 50 to 61 amps. We do not have a method for measuring pressure and shearing forces in the screw press and for that reason the energy input expressed in amperes at a constant voltage was used as a measure of pressing conditions.

Gossypol

The free gossypol shown on the table includes the gossypol and gossypol-like compounds which dissolve in 70 percent acetone under specified conditions; total gossypol is the free gossypol plus the gossypol that is hydrolyzed by oxalic acid under specified conditions; and bound gossypol is the total gossypol minus free gossypol.

Since preliminary experimental feeding tests with rats, chickens, and swine have demonstrated that bound gossypol is not appreciably toxic to farm animals, free gossypol rather than total gossypol has been used as a measure of the toxicity of cottonseed meal. Cottonseed meals

Processing Conditions and Properties of Experimentally Produced Cottonseed Meals

Run No.	Cooking Conditions		Press Conditions		Properties of Press Cake						
	Max. temp.	Time	Energy	Cake 5 min.	H_2O	Oil	Gossypol		Nitrogen		Thiamin
							Free	Total	Soluble	Total	
	°F.	min.	amps.	lbs.	%	%	%	%	%	%	ppm
S5-16	160	38	58	50	6.57	3.53	0.019	0.53	35.0	6.02	11.5
S1-8	178	20	60	50	4.6	3.3	0.011	0.40	14.3	6.9	7.07
S5-12	180	24	60	50	6.69	3.86	0.032	0.48	23.0	6.9	12.7
S5-10	180	24	50	50	6.26	3.88	0.041	0.57	41.4	6.12	15.08
S5-13	200	24	60	50	5.9	3.81	0.026	0.55	26.5	6.1	12.27
S5-1	230	37	60	60	6.54	3.46	0.026	0.615	15.3	6.62	7.84
S5-4	230	31	60	50	7.34	3.52	0.024	-	16.9	5.38	9.12
S1-5*	280	100	60	46	3.7	5.7	0.03	0.14	8.2	6.6	1.5
S4-1	184	25	50	61	3.33	4.48	0.037	0.74	45.2	6.9	-
S4-3	183	25	57	62	2.93	3.78	0.028	0.78	31.0	6.92	-
S4-4	182	25	61	62	2.88	3.54	0.019	0.80	26.0	6.93	-
S6-7	Butanone-extracted meal				7.38	0.28	0.027	0.14	72.3	9.04	33.7
S6-9	Essentially gland-free meal				8.16	1.5	0.06	-	85.3	10.1	39.5

* Water added to cooker at the rate of 70 lbs. per hour.

having a high content of free gossypol diminish the growth rate and, in extreme cases, caused the death of certain experimental animals, while meals with less than 0.04 percent of free gossypol gave excellent growth rates with swine whose diets contained as much as 43 percent of cottonseed meal. Essentially all of these experimentally prepared screw-press meals were non-toxic to farm animals; however, preliminary tests on the hatchability and discoloration of eggs made by the Bureau of Animal Industry indicated that cottonseed meals containing much less than 0.04 percent free gossypol may be needed in diets for laying hens.

Gossypol and other pigments are contained in glands in the cottonseed. When the glands are ruptured, some of the gossypol escapes and combines with other components of the meal to form bound gossypol. Other chemicals besides the meal components may also combine with gossypol. Some of these new compounds may be toxic while others are non-toxic. In the Southern Regional Laboratory, glycine has been combined with gossypol to form a product that is entirely non-toxic to rats and mice, and at this meeting the North Carolina Experiment Station is reporting on the use of iron salts to reduce the toxicity of gossypol.

Pigment glands can be ruptured in a number of different ways. For example:

(1) Chemicals such as some of the ethers, alcohols, and ketones rupture pigment glands and dissolve the gossypol;

(2) In many hydraulic oil mills and in some of the screw-press mills, cottonseed meats are cooked at a temperature of about 250°F. with steam added to the cooker. The combination of heat, moisture, and stirring in the cooker ruptures many of the pigment glands with a consequent decrease in free gossypol. However, in this procedure the nutritive value of the protein is lowered by high temperature cooking;

(3) In our experimental screw-press runs, in which low temperature cooking was used, nearly all of the glands were intact after cooking and practically all of the gossypol was present as free gossypol. After pressing essentially all of the glands were broken and the free gossypol content had dropped from 0.06 percent to less than 0.04 percent. In this procedure, free gossypol is changed to bound gossypol during the passage of meal through the screw press — without exposing the protein to high temperatures and moist heat.

Effect of Heat on Protein

The nutritive value of vegetable proteins is lowered by excessive heating, especially by moisture and heat. The cause of this heat injury is not definitely known, but a number of investigators have suggested that vegetable proteins are modified by heat to the extent that some of the essential amino acids are not absorbed in the digestive system of animals at the right time to be available for re-synthesis to body protein.

Some of the preliminary results of feeding tests indicate that the experimental screw-pressed meals processed at temperatures below 200° F. have a much higher nutritive value than those processed at the higher temperatures (230 to 250° F. or higher) now generally used in screw-press oil mills.

Methods to Determine Heat Damage

Food and feed processors are in need of a rapid laboratory test to determine the extent of heat damage to proteins in processing operations. Soluble nitrogen and thiamin determinations, as well as electrophoretic analysis of protein fractions, are being studied in the Southern Regional Laboratory.

The electrophoretic analyses indicate that there is a regular change in the composition of the protein mixture as a function of time and temperature of cooking.

Soluble nitrogen has been defined as the percent of nitrogen soluble in half molar salt solution under specified conditions. The soluble nitrogen content of these experimental meals varied from about 8 to about 82 percent. Although the correlation between soluble nitrogen and nutritive value has not been especially good, in general those meals with a high content of soluble nitrogen also have had high nutritive value and those with a low content of soluble nitrogen have had low nutritive value. When the maximum temperature in the cooker was under 200 ° F., the soluble nitrogen content of the meal was usually above 25 percent. The effect of energy input to the press on soluble nitrogen is illustrated in Runs S4-1, -3, and -4. At 50 amperes the soluble nitrogen content was 45 percent and at 61 amperes it was reduced to 26 percent. If screw-press meals with a soluble nitrogen content of 45 percent are superior to those with a soluble nitrogen content of 25 percent, and if efficient oil extraction can be maintained with a low energy input to the press, operating conditions such as those used for Run S4-1 are desirable.

Thiamin, or vitamin B_1, has been determined by chemical and by microbiological procedures. The experimentally processed screw-press meals contained from 1-1/2 to 15 parts per million, while meals S6-9 and -10 had 39-1/2 and 29.8 parts per million, respectively. This would indicate that some of the thiamin was destroyed during screw-press processing. However, the thiamin values of the screw-press meals appear to correlate quite well with the nutritional values reported.

Summary

It has now been fully demonstrated that non-toxic, highly nutritive cottonseed meals can be prepared by screw-press procedures. Factors determining the quality of the meals are the nutritive value of the proteins, the amount of protein, and the content of free gossypol. Nutritional investigations indicate that the objective in processing should be to produce meals with a low gossypol content without subjecting the cottonseed to excessive heat which damages the protein.

DISCUSSION

Question (Ward): What is meant by less energy applied to the press?

Answer: Energy was measured in amperes of electricity used by the motor in operating the press. We do not have any accurate means of determining temperature, pressure, and shearing forces in the screw press, and for that reason have used amperage at a constant voltage as a measure of these factors.

Question (Ward): How did you change the processing conditions from those usually employed in screw pressing operations?

Answer: Most screw press plants use high temperatures, cooking up to 270°F. Many operators also add water and cook for 30 or 40 minutes. This reduces the free gossypol content but lowers the nutritive value of the meal. It is suggested that meals be cooked without the addition of water to the cooker and at temperatures below 200°F.

Question (Ward): What was the difference in the oil extraction?

Answer: Good oil recovery was obtained in the preparation of these experimental meals. No actual mill-scale oil runs were made. After the conference, if we can decide on optimum processing conditions, a sufficiently large quantity of seed will be processed to get reliable data on the oil as well as the meal. The present indications are that low temperature processing gives good oil quality and yield.

Question (Lyman): Are high temperature necessary to bind gossypol?

Answer: No, the pressure in the press seems to result in the binding.

Question (Kruse) Is moisture in the meal acting as a lubricant in the screw press? Are the better results with dry meals due to the increased friction or shear resulting from the absence of water?

Answer: We are not positive, but we think the absence of water results in greater shear.

Question (Keller): Are temperatures cited in the tables cooking temperatures or barrel temperatures? Was the press water-cooled?

Answer: Temperatures are cooking temperatures. The press was water-cooled.

Question (Keller): What is the significance of the moisture variation in the various experimental screw-press meals?

Answer: Differences in moisture were not very great.

(Mr. Williams of South Texas Cotton Oil Co. pointed out that considerable time often elapsed between taking of the sample and determination of moisture. Therefore moisture content obtained may not reflect the true moisture content of the sample in the press.)

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NUTRITIONAL VALUE AND AMINO ACID AVAILABILITY OF COTTONSEED MEALS. Series 1 and 5.* (ABSTRACT)

by

M. J. Horn

Bureau of Human Nutrition and Home Economics

Ten cottonseed meal samples comprising Nutritive Processing Series No. 1, with a solvent-extracted meal as control, were fed at a level of 10 percent protein to young male rats. The protein efficiencies (grams gain per gram of protein consumed) varied from 0.54 to 2.26 for the experimental meals, indicating that the protein is considerably altered in nutritive value by the various processing treatments.

In one series of experiments, Vitamin B_{12} was added to the control (solvent-extracted) meal ration. An increase in the protein efficiency from 2.50 to 2.70 indicated that this vitamin is not present in optimum amounts in cottonseed. The meals are listed below according to their protein efficiencies:

Control meal and vitamin B_{12}	2.70
Control Meal	2.50
Series 1, No. 6	2.26
Nos. 2, 7, and 8	2.06
Nos. 1,3,4, and 9	1.74
No. 5	0.54

Seven of the cottonseed meals of Series 5 have also been fed at the 10 percent protein level to young rats. In this Series only meal No. 1, with a protein solubility of 15.3 percent, showed a protein efficiency significantly lower than that of the other meals, whose protein solubilities varied from 23.0 to 42.2 percent.

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* See Appendix, pp. 67 and 68, for tables describing these meals.

Because the animal experiments showed that there were great differences in the nutritive value of the proteins of the first series of cottonseed meals, studies on the essential amino acids were made in an attempt to find out what changes had taken place in the proteins to cause these differences. Acid and enzyme hydrolyses were made on each sample, and the meals were assayed for the ten essential amino acids.

The data obtained on these analyses showed that there was not only an actual destruction of the amino acids by some methods of processing, but also a "binding" effect which made the proteins undigestible to enzymes. This effect on the "availability" of the essential amino acids to the microorganism differed widely for the several meals, depending on the processing.

A comparison of the results from enzyme treatment of the processed meals with those of the standard meal was used to indicate the degree of "availability" of each amino acid, using the standard meal as 100. Although it is recognized that all the amino acids may not be limiting, the sum of the percentages of availability for all the essential amino acids in each meal was used to give an index of the nutritive value. According to these "indices", the meals of Series 1 were aligned in three groups in the following order of decreasing nutritive value:

Group 1 - Nos. 8, 7, and 6

Group 2 - Nos. 4, 9, 2, 1, and 3

Group 3 - No. 5

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DISCUSSION

Question: What was the standard meal used in the analyses?

Answer: Standard meal was a de-glanded meal in Series 1 and a methyl-ethyl-ketone-extracted meal in Series 5. These meals were not heated during their preparation.

Question: Were these meals the same ones described by Dr. Thurber?

Answer: Yes, Series 1 and 5 meals.

Question: What is the factor which removes arginine from solutions on standing.

Answer: It may be gossypol which combines with the arginine. If not, it is an unknown factor.

Question: Would this affect the nutritive value?

Answer: Yes, it would bind it up and make it unavailable to animals.

Question: Your amino acid analyses show large differences for the various processing conditions. This is surprising to me since in my experience I have not found such differences in my analyses of a wide variety of meals.

Answer: Amino acid analyses reported here are based on enzymatic hydrolysis which gives the amino acids which are bound and, therefore, not available. Acid hydrolysis gives the total amino acid content and, therefore, can only give information as to the amino acids actually destroyed during processing.

Question: Did you use the acid hydrolysis method?

Answer: Yes. That probably explains the difference.

Question: How did you arrive at amino acids destroyed during processing?

Answer: By acid hydrolysis.

Question: What about the histidine destruction?

Answer: The analysis of histidine was made by enzymatic hydrolysis.

Gastrock: The data show that butanone extracts something which affects the availability of the proteins, and that the protein of the methyl-ethyl-ketone-extracted meal (standard meal) is available to the animals. The SRRL has several solvent-extracted meals available for use in Nutritional work. These meals are butanone, acetone, and benzene extracted.

Horn: Would be very pleased to obtain some of these solvent-extracted meals. Will discuss this with you later.

EFFECT OF PROCESSING VARIABLES ON NUTRITIVE VALUE OF COTTONSEED MEAL FOR POULTRY AND SWINE (ABSTRACT)

by

N. R. Ellis
Bureau of Animal Industry

Various batches of cottonseed meal of Series 1 (see Appendix, p. 67) supplied by the Southern Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, were fed to poultry and swine to measure variations in nutritive value due to processing treatment.

Cooking temperature exerted a marked influence on the value of expeller-produced meals as measured by the growth of chicks. From our tests, it appeared that the supply of available lysine and the percentage of soluble nitrogen both decreased as the cooking temperature rose; 200°F. being considered the maximum for good results. Length of cooking period had little influence. Meals containing up to 0.1 percent of gossypol were fed with safety in amounts up to 39 percent of the diet of chicks; and when the gossypol fraction was 0.02 percent or less, as much as 70 percent of meal could be fed.

Tests with swine have shown that expeller-produced meals can be superior in feeding value to hydraulic-produced meals and approximately equal to the better grades of soybean meal.

Like the chick growth results, decreasing the cooking temperature of the meals from maxima of 230°F. down to 180°F gave increasing growth rates in pigs. The best meal with an indicated free gossypol content of approximately 0.04 percent, and fed at a level of 31 percent of the diet, was equal to soybean meal as a protein supplement to the basal diet composed of corn, alfalfa meal, minerals, and Vitamin B_{12} concentrate.

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DISCUSSION

Question: Did the feeding efficiency follow the rate of gain?

Answer: Yes, in a general way.

Question: Did the efficiency rating go down with the rise in temperature?

Answer: Generally yes.

THE EFFECT OF GOSSYPOL ON EGG HATCHABILITY, WEIGHT AND EGG COLOR (ABSTRACT)

by

B. W. Heywang
Southwest Poultry Experiment Station, BAI

Data were obtained in three experiments with mature White Leghorn chickens.

In the first experiment, hatchability was not affected when cottonseed meal or raw decorticated cottonseed furnished .012 percent or less gossypol to the diet, but hatchability decreased appreciably when they furnished .016, or .024, or .036 percent gossypol to the diet. In eggs that were held in cold storage, the degree of yolk discoloration attributable to gossypol increased as the free gossypol content of the diets increased.

In the second experiment, pure gossypol at the .012, .024, and .036 percent levels, respectively, was mixed fresh every two days with a diet fed to three groups of chickens. Gossypol had an appreciably adverse effect on hatchability and egg weight at the .024 percent level, and a still greater adverse effect at the .036 percent level, but did not affect either at the .012 percent level. Hatchability and egg weight returned to normal after gossypol feeding was stopped.

The procedure in the third experiment was similar to that in the second experiment, except that the mixed diets were allowed to stand for five days and then fed on the sixth and seventh days. Hatchability and egg weight were not affected, thus indicating that the gossypol was either destroyed or rendered inactive before the diets were fed.

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DISCUSSION

Question: Is there any loss of free gossypol in the meals on standing?

Answer: This is not known for certain.

Question: What are the recommended safety limits of gossypol content with respect to hatchability.

Answer: Below .012 percent of the total ration.

Question: And for yolk discoloration?

Answer: At 0.008 percent of the ration, free gossypol had an effect on yolk color. These figures are percentages of the total diet so that the percentages of gossypol in the cottonseed meals used would be higher. That is, with 20 percent cottonseed meal in the ration the gossypol content of the cottonseed meal would be 5 x 0.008 or 0.04 percent.

Question: What is the effect of bound gossypol on egg coloration?

Answer (Heywang): We are not sure about this.

(Lyman): Experiments on isopropanol extracted meals indicate that bound gossypol does not affect yolk color.

Question: Has gossypol been recovered from egg yolks which are discolored?

Answer: No work has been done on this. The yolks are discolored, but we do not know in which form the gossypol is present.

Question: Gossypol at 0.008 percent of the ration caused discoloration. Was this tried at the 0.004 percent level?

Answer: No work has been done on levels below 0.008 percent so far. Hence, we do not know the threshold level, but only that some coloration is obtained at the 0.008 percent level.

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† COTTONSEED MEAL TOXICITY STUDIES. (ABSTRACT)

by

K. T. Holley
Georgia Agricultural Experiment Station

When corn was used as the source of carbohydrate in swine rations containing 20 percent cottonseed meal in dry lot feeding the usual heavy losses were incurred, but if the animals had access to pasture very few died. Barley substituted for corn in dry lot feeding reduced the losses to about the same level as pasturage. Very young pigs were used to start these feeding trials.

The results obtained with pigs were not reproduced when weanling rabbits were used as the test animals. In part, this is due to greater sensitivity of the young of this species than of young pigs to cottonseed meal toxicity. Studies with these sensitive animals emphasized the significance of hemorrhages in cottonseed meal and gossypol toxicity.

Gossypol and toxic cottonseed meal lower the prothrombin of the blood of both rabbits and pigs. This hypoprothrombinemia may be controlled by the use of peroxides in cottonseed meals. Such control of hypoprothrombinemia did not prevent hemorrhages nor death in rabbits, but did increase survival time in short trial periods. Pasturage reduced the hypoprothrombinemia in pigs, but greenstuff had no such effect on rabbits.

From these tests, it can be concluded that gossypol and cottonseed meal toxicity cause severe damage to, and hemorrhages in the tissues of various organs of the animal body. Young animals are extremely susceptible to such damage.

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DISCUSSION

Question: Was vitamin K effective in lowering the blood clotting time?

Answer: Vitamin K lowered the effect slightly. We do not think that vitamin K is involved here.

Question: Were any other changes noted in the blood?

Answer: Yes, the red blood cell count was lower. This same effect was given by dicumarols, although it was more pronounced than for gossypol

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STUDIES ON THE VITAMIN B_{12} ACTIVITY OF AND UNIDENTIFIED NUTRIENTS IN COTTONSEED FLOURS AND MEALS (ABSTRACT)

by

A. M. Hartman*
Bureau of Dairy Industry

Using rats as the test animals and growth and survival as criteria, two experimental lots of defatted, deglanded cottonseed flour and nine experimental lots of cottonseed meal prepared under different, known conditions were all found to be extremely deficient in vitamin B_{12} activity when fed in the diet at levels that varied from 20 percent to 86 percent. When supplements of vitamin B_{12} that were fully sufficient were fed along with some of these rations, that were adequate in all other known nutrients, results were obtained which gave some indication that such products may be deficient in some unidentified nutrient(s).

The results of tests for vitamin B_{12} in cottonseed meals of Series 5, from the Southern Regional Research Laboratory, are shown in the table below.

Six sets of littermate male rats were started in each experiment. Figures in parentheses indicate the number of rats, when less than six, that are represented in the average, the remainder having died during the test.

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*Not present at the conference. Abstract read by A. M. Altschul, Southern Regional Research Laboratory.

Experiment No.	Cottonseed Meal No., and Av. 4 weeks weight gain in grams (All meals are from Series 5 — described in Appendix, p. 68						
	No B_{12} Fed				B_{12} Fed (1 mcg./10 g. ration)		
1	Casein 74	#16 80	#1 62		#16 166	#1 164	Casein 167
2		#16 65(4)	#2 69(5)	#3 66(4)		#2 148	#3 163
3		#16 86(4)	#4 64(4)	#6 73(3)		#4 157	#6 165
4	(2 weeks values, to date)	#16 39(5)	#7 42	#9 41		#7 88	#9 90

COTTONSEED MEAL AS A SOURCE OF PROTEIN FOR GROWING CHICKS (ABSTRACT)

by

J. R. Couch

Texas Agricultural Experiment Station

A number of reports have been published during the past few months, describing the use of cottonseed meal as the protein concentrate in broiler rations. In all cases, the supplementation of cottonseed meal with vitamins and minerals in a broiler feed resulted in a failure of growth. When DL-lysine was added to such a diet, growth was improved but was still suboptimum. Cottonseed meals of low gossypol content (0.02 - 0.03 percent) were used in the above-mentioned tests.

Experiments conducted at the Texas Agricultural Experiment Station have been of two types. In the first, 25-50 chicks were maintained in standard chick batteries with raised screen floors. In the second, 280 chicks were reared in brooder houses with sand litter, allowing 0.7 of a square foot of floor space per bird. Straight-run New Hampshire chicks were used in most of these tests.

The basal diet used in these studies was composed of 35 percent soybean oil meal, 2 percent steamed bone meal, 1.5 percent limestone or oyster shell, 1/2 percent salt, 3 percent dehydrated alfalfa leaf meal, 1/8 percent fortified fish oil (3000A-400D) and 57-7/8 percent ground yellow corn. In addition, 2 milligrams of riboflavin and 5 milligrams of calcium pantothenate were added per pound of feed, as well as 5-10 grams of manganese sulphate per 100 pounds of feed.

This diet was fed with and without a B_{12} supplement, and also with a supplement containing both B_{12} and an antibiotic. Concurrently, other groups of chickens were fed the same diet with all of the soybean oil meal replaced by cottonseed meal, with the latter supplemented with DL-lysine, and with only one-half of the soybean oil meal replaced by cottonseed meal.

Results obtained to date show that it is not necessary to add an animal protein concentrate to the soybean oil meal-corn ration when a B_{12} supplement is fed. On this ration, broilers that weighed 3-1/4 pounds at 10 weeks of age were produced, and 33-35 pounds of chicks per 100 pounds of feed were obtained.

When cottonseed meal was substituted for all the soybean oil meal, very poor growth resulted. When the cottonseed meal was supplemented with DL-lysine, growth was definitely improved but was still somewhat below that obtained with the diet which contained 35 percent soybean oil meal. Results obtained by substituting 17-1/2

percent cottonseed meal for an equivalent amount of soybean oil meal were also somewhat poorer than those obtained by feeding the ration containing 35 percent soybean oil meal.

During recent months, samples of cottonseed meal have been obtained from the Southern Regional Research Laboratory and from Buckeye Cotton Oil Company, Cincinnati, Ohio. Results obtained by feeding these specially processed meals indicate that the feeding value of the cottonseed meal has been improved by processing.

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EFFECT OF DIFFERENT COTTONSEED MEALS ON THE GROWTH AND FEED EFFICIENCY OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE.

Supplements to basal diet	Average Weight in Grams		Grams of feed required to produce grams of gain (Feed efficiency)
	Cockerels	Pullets	
None	1100.9	864.1	3.15
Series 5, No. 1	888.3	751.4	3.49
Series 5, No. 1 + 0.6% DL-lysine	1040.0	919.7	3.16
Series 5, No. 14	1007.4	739.6	3.59
Series 5, No. 14 + 0.6% DL-lysine	1064.2	962.5	3.19
Series 5, No. 9	906.9	821.9	3.39
Series 5, No. 9 + 0.6% DL-lysine	1074.8	873.3	3.17
Special Solvent-extracted meal	1027.5	880.0	3.42
Special Solvent-extracted meal + 0.6% DL-lysine	1093.2	870.5	3.03

HOG FEEDING TESTS WITH SPECIAL PROCESS COTTONSEED MEALS (ABSTRACT)

by

Fred Hale*
Texas Agricultural Experiment Station

Seven groups of 7 pigs each were fed individually on experimentally processed cottonseed meals. The effect of adding APF (Lederle No. 5) to two of these meals was studied. One group of pigs was fed a ration with meat scraps replacing cottonseed meal.

With one of the cottonseed meal groups, when APF was added, the pigs gained 29.6 pounds more per pig for the 84-day period, and required 31 pounds less feed per 100 pounds of gain, than did the check lot. Another cottonseed meal group with APF added gained 29.7 pounds more per pig, and required 40.6 pounds less feed per 100 pounds of gain, than did pigs in the check lot.

The pigs getting meat scraps required more feed per pound of gain, and did not make any greater gain, than did the APF-cottonseed meal fed pigs.

The results of these tests are summarized in the following tables. (The Series 5 meals referred to are described in the Appendix, p. 68).

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* Not present at the conference. Paper read by C. M. Lyman

RATIONS USED IN COTTONSEED MEAL FEEDING TRIALS WITH FATTENING PIGS

Ration	Lot No. 1	2	3	4	5	6	7
Ground Milo	79	77	79	79	81	81	84
Cottonseed Meal	Series 5, No. 1	Series 5, No. 9	Series 5, No. 14	Series 5, No. 14	Isopropanol-extracted		
	16	18	16	16	14	14	0
Meat Scraps							12.5
Alfalfa Leaf Meal	3	3	3	3	3	3	3
Limestone	1.5	1.5	1.5	1.5	1.5	1.5	0
Salt	0.5	0.5	0.5	0.5	1.5	1.5	0.5
Lederle APF #5 (lb./100 lb feed)	0	0	0	0.5	0	0.5	0

Results of Feeding Cottonseed Meal to Fattening Pigs - APF Series

Test began June 21, 1950 - Closed September 13, 1950 (84 days)
All pigs fed in individual pens

	Lot 1 C.S.M. Series 5, No. 1	Lot 2 C.S.M. Series 5, No. 9	Lot 3 C.S.M. Series 5, No. 14	Lot 4 C.S.M. Series 5, No. 14 + APF	Lot 5 C.S.M. Iso-propanol extracted	Lot 6 C.S.M. Iso-propanol extracted + APF	Lot 7 Meat Scraps
Number of Pigs per Lot	6*	6*	6*	7	7	7	7
Length of Test (Days)	84	84	84	84	84	84	84
Average Final Weight (lbs.)	195.6	191.8	186.8	214.8	191.4	221.1	216.6
Average Initial Weight (lbs.)	68.6	68.6	68.3	66.7	66.7	66.7	66.7
Total Gain (lbs.)	127.0	123.2	118.5	148.1	124.7	154.4	149.9
Average Daily Gain (Per Head - lbs.)	1.51	1.46	1.41	1.76	1.48	1.84	1.78
Feed per 100 lbs. Gain	411.0	394.3	406.6	375.0	406.0	365.4	393.7
Total Feed Eaten	3132	2914	2891	3889	3545	3950	4130

* One pig removed from test because of unthriftiness.

DISCUSSION

Question (Rusoff): Some of the APF we had contained 5 to 7 percent protein. Would this protein content affect the results given?

Answer: The quantity of APF fed was such that its protein contribution is insignificant.

Question (Salmon): What was the initial weight of the pigs used in the experiment?

Answer: About 24 pounds.

Question (Cunha): What about previous treatments of these pigs -- had they been on rations?

Answer: Yes. They were not depleted pigs. We found that it was unnecessary to deplete pigs in order to get the APF effect.

Question: Is this unknown growth factor you believe to be present in cottonseed necessary to show up the advantage of dried whey?

Answer: I don't know at present. Perhaps improved processing of cottonseed might allow the factor to be better demonstrated; that is, if the factor were present in higher concentrations it would show up better.

Question (Rusoff): Do you think that a low free-gossypol content and a high lysine-content might be responsible for this growth factor effect?

Answer: We checked the free-gossypol content of the meal and found it to be 0.03 percent. I don't think lysine entered the picture because lysine was at the 1 percent level which exceeds the chick requirement.

Question (Horn): Did you include a deglanded meal like the standard meal used in my tests?

Answer: No. S. R. R. L. didn't have a sufficient quantity available at the time the tests were started.

THE USE OF DETOXIFIED COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR GROWING PIGS (ABSTRACT)

by

E. L. Stephenson
University of Arkansas

An experiment was designed to study the effect of feeding different cottonseed meals to weaned pigs. The cottonseed meal was fed at a level calculated to supply the total supplementary protein needed. An additional 6 percent of fish meal was added to compensate for amino acid or APF deficiencies.

Of the three meals studied, two were very toxic. The pigs receiving them died between four and six weeks after being placed on the experimental diets. The other meal, (Series 1, No. 8) an experimental product obtained from the Southern Regional Research Laboratory (see Appendix, p. 67) was non-toxic, even when fed at levels as high as 43 percent of the total diet.

In another test the experimental, non-toxic meal was studied to determine whether amino acid or APF supplementation would improve it. The results of this study indicated that lysine would improve the meal, but methionine and APF were of little or no supplementary value.

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THE USE OF DETOXIFIED COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR LAYING HENS (ABSTRACT)

by

E. L. Stephenson
University of Arkansas

White Leghorn hens, divided at random into three groups of fifteen hens each, were placed on experimental diets as follows: All hens received an all-vegetable diet, only variable being the source of protein. The protein supplements were as follows:

Group 1 - An experimental cottonseed meal, expeller process (Southern Regional Research Laboratory Series 1, No. 8, described in Appendix, p.67)

Group 2 - A commercial cottonseed meal, solvent process

Group 3 - A commercial soybean meal, solvent process

The eggs produced by these hens were collected daily and placed in storage at a temperature of 40°F. Twenty eggs from each group were broken at monthly intervals, and examinations made of the yolk and albumin color.

After the third month of storage, all eggs from the hens in Group 2 had live-colored yolks and pink albumin. After six months of storage, at which time the experiment was ended, there was no discoloration of either the yolk or albumin of eggs from Groups 1 and 3. From these data, it appears that the experimental cottonseed meal might have commercial value for feeding laying hens.

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DISCUSSION

Question (Lyman): What was the free-gossypol content of cottonseed meal No. 8 used in these experiments?

Answer: It was 0.008 percent.

Question (Upp): Were the eggs used in your studies held at 40°F. to accelerate the rate of discoloration?

Answer: No.

Question (Kuiken): What was the free-gossypol content of the two commercial meals?

Answer: On the solvent-extracted meal it was 0.10 percent and on the hydraulic-pressed meal 0.06 percent.

PRELIMINARY OBSERVATIONS ON SUPPLEMENTING VARIOUS CORN-COTTONSEED MEAL RATIONS (ABSTRACT)

by

T. J. Cunha
Florida Agricultural Experiment Station

Four different cottonseed meals were compared in feeding value for growing-fattening pigs (Duroc and Hampshire) fed in dry lot. All rations contained corn, vitamins A and D, minerals (including trace minerals), and cottonseed meal to bring them to approximately 19 percent total protein. The pigs (4 pigs in each lot) weighed about 25 pounds when started on these trials.

Following are the rations fed and some of the results obtained during a period of nine weeks:

Lot No.	Cottonseed meal	Percent free gossypol	Avg. daily gain	Daily feed intake	Feed per 100 lbs. gain	Grams of free gossypol eaten daily
1	Commercial solvent-extracted	.063	0.26	2.25	865	0.22
2	Commercial hydraulic-press	.098	0.50	2.34	468	0.36
3	Commercial screw-press	.075	0.20	1.65	825	0.20
4	Southern Lab. expeller	.024	0.83	2.78	335	0.10
5	Lot 4 + 7 B-vitamins		0.66	2.44	370	0.09
6	Lot 4 + 7 B-vit. + lysine		0.62	2.23	360	0.08
7	Lot 4 + 7 B-vit. + lysine + methionine		0.68	2.37	349	0.09
8	Lot 4 + 7 B-vit. + lysine + methionine + APF		1.31	4.10	313	0.15
9	Commercial hydraulic-press + high level of vit. A and B_1		0.42	1.80	428	0.27

Very poor results were obtained with the commercial solvent-extracted and the commercial screw-press cottonseed meals. In spite of the fact that the commercial hydraulic-press meal was higher in free gossypol (Lot 2) and the pigs ate more of that ration (thus consuming more free gossypol), the pigs still gained faster and were considerably more efficient in feed utilization than the pigs fed the lower gossypol meals in Lots 1 and 3 (commercial solvent-extracted and commercial screw-press). This tends to indicate that the differences obtained were most likely not due to the free gossypol content, but possibly to differences in protein quality or availability which may have been brought about by the different processing methods. The U. S. Southern Laboratory expeller cottonseed meal (Series 5, Nos. 6 and 7, described in Appendix, p. 68) gave the best results in rate and efficiency of gain as well as in appearance and condition of the animals.

The addition of seven B-complex vitamins to the Southern Laboratory meal caused a decrease in feed consumption, rate of gain, and efficiency of feed utilization. This may have been due to some imbalance. The addition of lysine alone and of lysine plus methionine was of no benefit

in stimulating growth under the conditions fed. The addition of the Lederle aureomycin APF supplement in Lot 8 caused a considerable increase in the rateof gain and a small increase in efficiency of feed utilization. In Lot 9 the addition of a very high level of vitamin A (50,000 I.U. daily) and thiamine (10 grams per 100 pounds of feed) was of no benefit in increasing rate of gain or in preventing deaths due to gossypol poisoning.

Three pigs were dead in lot 2 by the 55th day: three pigs died in lot 3 by the 46th day: and two pigs were dead in lot 9 by the 55th day. In spite of the fact that the pigs in lot 3 (commercial screw-press meal) were consuming only about one-half as much free gossypol as those in Lot 2 (commercial hydraulic-press meal), they died about one week earlier in each case. Again, this raises the question as to whether free gossypol alone was responsible for the deaths.

In Lot 5, where the seven B-vitamins were added, the Duroc pigs developed a lighter color. As the hair faded to a light yellow, grey hair also started to appear and, in one case, a pig developed almost all grey hair. This same effect in hair coat color (fading and grey hair) occurred in Lots 6 and 7. This means that lysine did not prevent the fading hair coat color. However, in Lot 8, where the Lederle APF was fed, there was no fading of hair coat color. The hair remained bright red, as is characteristic of Duroc pigs. Thus, it seemed that the APF prevented a fading in hair coat color which was accentuated by adding the seven B-vitamins to the ration. (In Lot 4, where the seven B-vitamins were not fed, the fading of hair coat color was only slight).

* * *

DISCUSSION

Question (Dyer): Was the response to APF due to the antibiotic or to the B-vitamins?

Answer: To a combination of both.

Question (Rusoff): What do you think about B-vitamin effects?

Answer: The 7 vitamins added to the cottonseed meal probably caused an imbalance which would not occur with corn or soybean meal.

Question (Rusoff): Dr. Stephenson noted a mangy condition in the hogs he used.

Answer (Stephenson): No bleaching of the hair coat of Duroc pigs was apparent.

Question (Holley): Was skin dermatitis noticed when solvent-extracted meal was fed?

Answer: Yes. Dermatitis was worse on pigs receiving solvent-extracted cottonseed meal, but was also present on pigs receiving all of the other meals except the one from the Southern Regional Laboratory. Addition of B-vitamins did not prevent it.

(Holley said the late Dr. Sewell had attributed such a mangy condition to residual hydrocarbons in the meal fed. A question was raised as to whether the addition of alfalfa meal to solvent-extracted meal would correct skin coat bleaching. H. D. Fincher said the presence of alfalfa meal in the ration had been found to prevent bleaching.)

Question (Singletary): Was the condition of the tongue noted in the test pigs?

Answer: Yes. We fed vitamin A capsules every week and the pigs had black tongues a week before the mangy skin condition appeared.

(Dr. Singletary said that he had produced such skin eruptions and ulcerated tongues by feeding rice bran and shrimp meal but when meat scraps were substituted the condition cleared up. Dr. Cunha pointed out that hydraulic-pressed peanut meal causes similar skin conditions.)

Question (Fincher): Did APF help the mangy condition?

Answer: No. The pigs were too far gone to be benefited by APF. We found thiamin in the tissues of the animals. The addition of thiamin to the ration had no effect.

(Fincher said that as a rule, commercial cottonseed meals are usually higher in vitamin B_1 than most other concentrates.)

Alderks: In certain of our tests Duroc pigs receiving a low free-gossypol hexane-extracted meal were losing weight rapidly and had a mangy skin condition. We switched to another solvent-extracted meal and the pigs grew a new normal coat of hair and gained weight rapidly. No other dietary supplement was used. Both of these were experimental meals, produced in the same pilot plant.

Stephenson: Even the addition of herring meal to the diet of mangy Duroc pigs did not aid the skin condition in our tests.

Question (Fincher): Is there any relation between this bleaching in pigs and that noted by Dr. Davis in cattle on mineral-deficient areas in Florida?

Answer: I don't think it is the same. We added 5 times the recommended amounts of minerals. It is possible that iron is involved.

Rusoff: Bleaching might be due to copper deficiency. Several years ago we analyzed many types of cottonseed meals and found wide variations in copper content.

Cunha: We included copper in the ration. Maybe it was inadequate in amount.

Ellis: Even though a supplement of 7 B-vitamins is added, the diet may be deficient in pantothenic acid. Sometimes spraying with benzene hexachloride. I suggest that not too much significance be attached to skin coat condition.

Horn: The work of my associate, Dr. Womack, showed that all of the rats fed on Series 5 meals turned grey.

Question (Watts): Does the addition of Lederle APF with the 7 B-vitamins help?

Answer: Where APF was used, the addition of the B-vitamins had no effect.

Dyer: We noted that crystalline vitamin B_{12} partially relieved bad skin condition. The results were the same whether the Merck product or some other was used.

Question (Roos): There are wide differences of opinion on the effect of using APF and vitamins. I wonder if some of the gains in weight reported might not be due to differences in feed intake? The APF induces remarkable gains but I think that a general diseased condition of hogs should receive more attention.

Answer: In some cases there was a two-fold increase in feed intake. However, on high-gossypol cottonseed meals APF sometimes induced weight gains of 10 to 75 percent.

Singletary: We fed an animal protein supplement and still got a mangy condition. We also fed cottonseed meal at the 16 percent level and with 1 percent ferrous sulfate in an all-vegetable protein supplement, and the pigs gained normally without showing a mangy condition.

IMPROVING COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR SWINE (ABSTRACT)

by

E. R. Barrich
North Carolina Agricultural Experiment Station

The effects of supplementing commercial hydraulic-processed cottonseed meal with iron salts and APF concentrate (supplied by Lederle Laboratories Division, American Cyanamid Company through the courtesy of Dr. T. H. Jukes,) were investigated in a feeding trial using pigs having an average initial weight of 48 pounds.

The basal ration consisted of corn, cottonseed meal, alfalfa meal and added minerals and riboflavin. The control diet contained a mixed protein supplement of meat scraps, soybean meal, and cottonseed meal in lieu of the cottonseed meal of the test diet. The diets fed, the respective responses in terms of daily gain in pounds, and in the amount of feed consumed per 100 pounds of gain, during a 12-week period were as follows:

Diet	Daily Gain lbs.	Feed Consumed per 100 lbs. of gain lbs.
Basal	0.24	1128
Basal plus $FeSO_4$	0.91	515
Basal plus APF	High mortality rate makes data unsuitable for comparison	
Basal plus $FeSO_4$ and APF	1.22	381
Control diet	1.58	378

The results show that addition of iron salts to the basal diet prevented symptons of gossypol toxicity and improved the growth rate of the pigs. The APF concentrate, when fed with iron salts, gave an added growth response; but when fed without iron salts resulted in earlier symptoms of toxicity and in higher mortality than when no APF was fed.

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DISCUSSION

Question (Rusoff): What was the difference in feed consumption when the two commercial meals were used?

Answer: Feed consumption was approximately the same.

Question (Cunha): Didn't you say that APF improved appetite only when iron was added to the diet?

Answer: That is correct.

Question (Hoywang): What was the gossypol content of the diet to which ferrous sulfate was added?

Answer: It had 0.12 percent free gossypol.

Heywang: "Even if iron renders gossypol non-toxic it would not be practical to add iron to the diet because it forces hens out of production and might affect reproduction in swine.

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THE EFFECT OF PROCESSING VARIABLES ON THE AVAILABILITY OF THE ESSENTIAL AMINO ACIDS IN COTTONSEED MEAL (ABSTRACT)

by

K. A. Kuiken
Texas Agricultural Experiment Station

The availability of the essential amino acids in cottonseed meal was studied by a technique which involved feeding rats and determining the amount of the amino acid consumed and the amount excreted by way of the feces.

In preliminary studies of this type, it was observed that the availability of the essential amino acids in a commercial sample of cottonseed flour (Proflo) and in a typical hydraulic meal varied greatly. Although 95 percent of the arginine in these samples was available to the animals, only 65 percent of the lysine and methionine was available. Subsequent experiments were carried out in an attempt to determine what processing factors might influence the availability of these amino acids.

The following observations were made:

(1) The essential amino acids in raw cottonseed globulin are completely available.

(2) Amino acid availabilities above 90 percent were obtained with a solvent-extracted product of low gossypol content that had been prepared without heat. The availabilities of the amino acids in this product were not altered seriously by heat treatments ranging in severity to an extreme of autoclaving at 15 pounds pressure for one hour (about 250°F).

(3) The addition of 0.1 percent gossypol, as the pure compound or the equivalent amount of pigment glands, did not reduce amino acid availabilities appreciably even though mild heat treatment was used to effect binding of the gossypol.

(4) A raw hexane extracted product containing 1.2 percent free gossypol was found to have an arginine availability of 96 percent and a lysine availability of 84 percent. Values for other amino acids were within these extremes. Steaming for 30 minutes or autoclaving for 10 minutes reduced lysine availability to 80 percent.

(5) Screw press meals numbers 1, 9, and a combination of 5 plus 14, of the Series 5 products (described in Appendix, p. 68) distributed by the Southern Regional Research Laboratory, were also tested. These products were found to be very similar. Lysine availabilities were 75, 78 and 79 percent, respectively; values for all other amino acids were higher. A sample of isopropanol extracted meal was found to be essentially identical with these Series 5 meals.

Work is underway on evaluating the effect of heating cottonseed meal in the presence of cottonseed oil.

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DISCUSSION

Question (Rusoff): Could you commercially treat cottonseed meals with soluble iron salts to tie up the gossypol?

Answer (Alderks): It would be difficult to sell such treated meals and, therefore, would be impractical.

Question (Rusoff): Does gossypol become tied up with anything besides amino acids, such as minerals or other substances?

Answer (Markley): Yes. Gossypol might react with carbohydrates or with any other substance capable of reacting with phenolic compounds.

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FUTURE PROGRAM OF RESEARCH ON COTTONSEED MEAL

by

A. M. Altschul
Southern Regional Research Laboratory

I would like to discuss the work on cottonseed meal under three headings -- nutrition, fundamental research, and processing research.

I would like to ask what we know, what don't we know, and what are we doing about it in respect to those subjects.

Nutritional research

Let us take nutritional research first. I think that the first point clear from the reports made the last two days is that cottonseed meal is a variable material from the point of view of nutrition. In doing nutritional research with cottonseed meal one should be especially careful to identify his results with the particular meal studied. Another point that is quite clear is that a number of cottonseed meals which have good nutritive value and low toxicity have been produced in commercial mills. The third point is that cottonseed meal does not contain animal protein factors and that, generally speaking, supplementation with one or another source of APF enhances its growth-promoting ability.

There are also a few things we don't know. The first is the relationship of gossypol to the nutritive value of cottonseed meal. I think we can make this kind of a conservative statement: it has been found that meals with a free gossypol content of less than 0.03 percent, as determined by the methods developed at the Southern Regional Research Laboratory, seem to be non-toxic when fed to hogs in large quantities -- up to 45 percent in some of the experiments; and non-toxic to chicks when fed up to 70 percent of the diet. Does that mean we cannot go above 0.03 percent? Is 0.04 percent toxic? What is the limit of toxicity for hogs and chickens? We don't know. Nor do we know whether or not the improved cottonseed meal is a better feed for ruminants than the ordinary commercial product.

What is the best possible nutritional value that cottonseed meal can attain? Let us forget for the moment the practicalities of the problem and find out what is the upper limit.

In this laboratory we have taken a hexane-extracted cottonseed meal prepared under conditions of minimum heat. That meal, of course, contained all of the gossypol in a free form. That meal was extracted a second time with methyl-ethyl-ketone (mind you, we weren't interested in knowing whether this was a practical procedure or not -- we were simply interested to know whether we could get a meal of minimum heat denaturation and minimum free gossypol content.) The free gossypol content of the resulting meal was less than 0.02 percent. The protein had undergone very little denaturation and the thiamin value was about 35 parts per million; we had reason to believe that this was a nearly raw meal.

That is the meal Dr. Horn referred to yesterday as the standard for Series 5. The University of Arkansas is testing some of it and I think their results will indicate the top-limit possibilities of cottonseed meal as a feedstuff. It would be interesting to know how meals prepared by other methods, particularly isopropanol extraction, compare to this meal.

In considering materials which may interfere with the nutritive value of cottonseed meal, a few things have been clarified, some previously, and some at this meeting. It has been shown by Dr. Charlotte Boatner and her associates that pigment glands are toxic, but there is some question about the toxicity of gossypol. There is evidence that chronic doses of gossypol are toxic, but in tests of acute toxicity pigment glands have been found to be much more toxic than gossypol -- something like double.

That indicated two possibilities: (1) in pigment glands there is another material more toxic than gossypol, or (2) gossypol is associated in the pigment glands with some other material which increases its toxicity by changing its physical properties. We have evidence, at least by implication, that the reason pigment glands are more toxic in the acute dosage than gossypol is that the gossypol may be associated with carbohydrate in the pigment glands. A product made by combining gossypol and dextrose has been found equally as toxic as pigment glands in rat feeding tests. On the other hand, gossypol combined with glycine was completely non-toxic.

The effect of gossypol on egg color is a very important subject if cottonseed meal is to be used in poultry feeds. Tests reported at this meeting have shown that egg yolk discoloration can be produced by adding gossypol to the diet of laying hens, but it has also been shown that a cottonseed meal which does not cause egg yolk discoloration can be produced.

Meals having a free gossypol content of 0.01 percent or lower apparently will not cause egg yolk discoloration. We don't know how much higher we can go, if at all. That's another very important point that has to be settled.

Fundamental research

Now I'd like to raise a few fundamental questions. The first concerns the effect of cooking cottonseed meats. I think it has been well established in many laboratories that if cottonseed meats are properly cooked, preferably in a moist condition and with adequate stirring, the meals are completely detoxified. Thus, if we were simply measuring toxicity, we could say that cottonseed meals can be detoxified by wet cooking. Also, there are certain definite advantages to cooking cottonseed meats prior to putting them through an expeller or a screw press, or prior to hydraulic pressing. That is, the cooking exerts a beneficial influence on the further behavior of the meats in the press.

On the other hand, there seems to be evidence that cooking does not improve the properties of the oil; that probably higher temperatures of cooking, result in greater refining losses and more intense colors in the oil. I think we can also safely say, from the results of experiments reported at this meeting, that cooking does

not improve the protein value of cottonseed meals. I think it is rather clear that cottonseed protein is the type that doesn't require heating to improve its nutritive value. Furthermore, the evidence of feeding tests is that higher temperatures of cooking of meats give meals with lower protein value.

I believe, then, that we can summarize the effect of cooking by saying that it is possible to detoxify cottonseed meal and to improve press operations by cooking, but cooking probably does the oil no good, and certainly does the protein of the meal no good.

Just what is the effect of heat on the protein? I think that the evidence given at this meeting indicates that heat can actually destroy the amino acids of cottonseed protein. This is significant because the value of protein as a foodstuff lies in the fact that it is a source of amino acids. Besides actually destroying certain of the amino acids, it seems clear that heat reduces the availability of amino acids to the animals. That is, the amounts of amino acids in the proteins which are actually released by the digestive enzymes and made available to the animal by digestion or absorption and body processes are reduced.

Availability of the amino acids in cottonseed protein has been measured in two ways: by using an artificial stomach, so to speak, where the meals are subjected to isolated enzymes, and by actually using the rat as the digestive system and finding out exactly what happened.

Besides the effect on amino acids, investigations have shown that there is actually a change in the number of protein components of the meal on cooking -- that is, a profound change in the proteins themselves.

Why should cooking destroy the protein content of cottonseed meal? The answer is a guess. When proteins are heated in the presence of other materials, particularly carbohydrate materials, a reaction, loosely termed the "Browning reaction," takes place which serves either to destroy the amino acids or make them unavailable. Cottonseed meals contain carbohydrate materials, and it is quite possible that a similar mechanism is responsible for destruction of protein material during cooking.

Can we measure the destruction of protein in a laboratory? Obviously the best measurement is the feeding test, but this takes a long time and is expensive. A laboratory measurement introduced by Dr. Paul Cannon has been to deplete rats of proteins and then determine in a very rapid manner -- in a period of ten days -- the rate of build-up of blood proteins. That is the closest thing to a laboratory method now available.

At the Southern Laboratory we have tried testing for the "Browning reaction" but we cannot say that this method, is applicable. We don't intend to leave it out of our considerations, however. We hope to investigate it again.

It has been suggested that we use the effect of heat on the thiamin in the meal to indicate the extent of protein destruction, and we are giving this method our greatest attention. Let us clarify one point, though. It's entirely possible that thiamin itself, as a vitamin, exerts a profound effect on the nutritive value of cottonseed meal. At the moment, however, we are considering thiamin merely as a coincidental measure of the heat denaturation of the protein. It so happens that when the meal is heated and the nutritional value of the protein is reduced, the thiamin content also decreases. We are hoping that this coincidence is so close that one may use thiamin content as a measure of heat damage to the protein.

Now let us review fundamental work on detoxification. What is the mechanism of detoxification of cottonseed meal? Evidently, for meals to be detoxified, all of the pigment glands have to be broken. Whenever you have a meal with no evidence of toxicity, you cannot find any intact pigment glands.

How does one rupture pigment glands? The obvious way of doing it, and the way that has been most widely practiced, has been to cook the meals, etc. Wet-cooking of meals, which is a common practice serves the purpose of rupturing the pigment glands.

But there are other means. We believe that it is possible to destroy pigment glands by applying shear to the material. Straight, direct pressure does not have as profound an influence on the structure of pigment glands as does shear. We came to that conclusion when we noticed a fundamental difference between hydraulic-press operations and screw-press operations, and were unable to attribute the difference to cooking. It appeared that the significant difference between screw-press and hydraulic-press operations was the torsional pressure to which the meal is subjected as it goes through the screw press. Place some pigment glands between two microscope slides and press on them. You can press pretty hard and they do not break -- and then just rub them, and with hardly any pressure they will rupture.

Another method of rupturing pigment glands is by means of solvents. Many investigators have found that certain polar solvents, solvents which contain traces or larger quantities of water, are capable of bursting pigment glands.

Processing research

I think it is clear that the screw press detoxifies cottonseed meal without any trouble, and it has definitely been established that highly nutritive meals can be prepared by the screw-press method. We must now decide whether or not we can give out specifications on how to make screw-press meal that will have high nutritive value. Obviously, we cannot give complete specifications, but I think we can give tentative ones based on the results to date. Such specifications may be revised later. I want to make the suggestion that a screw-press

meal, in order to have high nutritive value, meet three qualifications:

(1) It should have a free gossypol content of 0.03percent or lower as determined by the Southern Regional Laboratory method. That may be revised to 0.04, depending on future experiments, but to be conservative I think one should say 0.03 percent.

(2) The meal should not be cooked at a temperature exceeding 200°F. There is some evidence that meals made at 160°F. are superior to those made at 200°F., but I think that anything under 200°F. would certainly be much better than anything on the market today.

(3) The meals should have at least 12parts per million of thiamin. Until a better method is devised, we can use thiamin content as a guide to the pressures to be applied in processing the meal.. Commercial meals that have been cooked at higher temperatures and put through the press at high pressure have vitamin contents ranging from about 4 to 7 parts of thiamin per million. The experimental meals of Series 5 have thiamin values ranging from 12 parts per million and up.

What does all this do to the oil? In our preliminary experiments it would have been very difficult to get a representative sample of the oil. You can get a pretty good sample of the meal, but when you try to take a representative sample of the oil it is pretty difficult. We have made arrangements with several of our cooperators to run their mills under the specified conditions that I have just listed, and to collect oil samples for comparison with oils from their regular production. When this is done we will have an accurate picture of the effect of these revised processing conditions and properties of the oils.

Just because the screw press is easier to work with doesn't mean that we can neglect the hydraulic press in our studies. It is our opinion that until all of the cottonseed meal produced has the highest possible nutritive value, the industry and the producers will not derive maximum benefit. Here's what we're doing in the laboratory in that respect. It goes back to the difference between hydraulic-press and screw-press operations. It is our feeling that somehow in the course of the hydraulic-press operation, shear should be introduced into the processing operation -- perhaps in the rolls, perhaps in some intermediary equipment. Perhaps more shearing can be introduced in the stirring of the cooker. It may be possible in this way to break the pigment gland and, therefore, make it unnecessary to subject hydraulic-pressed meals to such high temperature cooking conditions as are now used.

As to solvent extraction, I believe that this method will take firm hold in the cottonseed industry only when it has been definitely

proven that the products produced are equal, or superior, to the products produced by other means. There seems to be every evidence that solvent-extracted oil is equal, if not superior, to other oils. But how about the meals? In general, they need improvement, especially as to free-gossypol content, before they are suitable for non-ruminants.

Consideration should be given to more effective use of prepressing as a means of rupturing pigment glands. At the present time little advantage is taken of prepressing to reduce the free-gossypol content of the meal. Further research is necessary on prepressing from the point of view of the nutritive value of the meal.

Some of the work on mechanical rupture of pigment glands designed to improve the hydraulic press meal may also be applicable to solvent extraction as well.

By use of two successive extractions, one with hexane to remove the oil and the other with methyl ethyl ketone to remove the gossypol, we have produced a meal that has superior nutritive value. The use of successive or mixed solvents should be given careful consideration.

The work being done at this laboratory and the research underway in industrial firms gives rise to optimism that ways will be found to produce meals by solvent extraction which will have high nutritive value.

Summary

The outstanding thing that has come out of this meeting is that there is indeed a type of cottonseed meal which has high nutritive value for non-ruminants. I think that every Experiment Station in the country ought to get samples of this cottonseed meal for testing. And I think that industry should get as many of its members as possible to produce meals under the require conditions for obtaining improved products, and then encourage people to try them.

The cooperation of the cottonseed industry, of Mr. Ward and the Educational Service of NCPA, and of the nutritionists in both Government and State Laboratories has resulted in great progress in a short period. Continuation of this joint effort will certainly meet with success.

ROUND TABLE DISCUSSION

Heywang: Is meal containing 0.013 percent gossypol considered to be non-toxic, say in regard to egg yolk discoloration?

Altschul: On the basis of experiments reported by Dr. Stephenson, meals with a free-gossypol content of 0.01 percent do not affect eggs in storage. For growing chicks, the evidence seems to be that meals with less than 0.03 percent are non-toxic.

Heywang: Wouldn't it be better to express toxic levels in terms of gossypol fed in the diet rather than gossypol content of the meal?

Altschul: From the point of view of the cottonseed processing industry, it is preferable that standards of toxicity be based on the free-gossypol content of the meal. This is a basis over which they may have some control.

Heywang: The free-gossypol content can go to 0.04 percent in the case of chicks, but I don't believe you can go above 0.008 gossypol in feeding laying hens without having discoloration in the eggs.

Lyman: The effects of gossypol toxicity in chickens should not be confused with its effect on hogs, as hogs are by far more sensitive to gossypol. Even in the case of hogs there was no demonstrable toxicity in continuous feeding at the level of 0.03 percent gossypol. However, I feel sure that as the free-gossypol content is reduced below 0.03, increased growth rates will be obtained. This was illustrated by data given this morning. Meals which had 0.02 percent gossypol gave better growth than meals which had 0.027 percent gossypol in spite of the fact that they contained less soluble protein. Isopropanol meal which had 0.01 percent gossypol gave even better growth rates. So, while 0.03 percent gossypol does not produce toxic results, going to lower values generally results in improved growth rates.

Thurber: The Laboratory at present is preparing meals of known gossypol content which will be available for nutritional testing. Quantities of meal available are adequate for chick testing, and as the results of these experiments become available larger quantities will be prepared for use in hog feeding trials.

Kuiken: How will these meals be prepared?

Thurber: We will be glad to have suggestions. In all probability the meals will be prepared by blending cottonseed meals of different known gossypol contents so as to attain the desired gossypol level. Other suggestions on methods of preparation will be appreciated.

Lyman: I am not sure that hydraulic meal having 0.03 percent gossypol would give the same result as a solvent-extracted meal having the same gossypol content. This may be due to loosely bound gossypol.

Sherman: How long will it be before all cottonseed meals will be as high in quality as the experimental meals described in the conference? From the standpoint of my company — the Ralston-Purina Company — this has great importance. As a feed manufacturer it is to our interest to have a uniformly high quality product so that it will not be necessary to take cottonseed meal from one bin for use in poultry and swine rations, and from another bin for use in cattle feed. There is always the possibility that the feed mixer may become confused and costly errors result. Also we are interested in learning whether there is any information on variations in cottonseed meals from different sections of the country.

Altschul: This latter point is being investigated.

Ward: Dr. Markley, what is your opinion as to the effect of low temperature processing on the quality of cottonseed oil?

Markley: At present we are not in a position to know, but in all probability these conditions will be less drastic on the oil.

Ward: That is also the impression Dr. Altschul gave.

Altschul: I have seen reports of solvent-extracted oil extracted at low temperatures where there has been hardly any heat treatment at all, and these oils had very low refining losses. I wonder if some of the solvent extraction people here might not want to offer an opinion on the effect of low temperature on the refining loss of the oil.

Alderks: In line with Dr. Markley's remarks, the lower the temperature and the less exposure to atmospheric conditions, the better the oil will be. I think you have a good chance of doing this with screw-press operations providing you do not run more pigmented material and other things which would give a higher refining loss. Results should be obtained over more than one season since it is more difficult to remove the gossypol one year than in another. Also it is easier to remove gossypol from older seed than from freshly harvested seed. All in all, there are a great number of factors which must be considered.

Mays: What is the effect of cooking on refining loss of hydraulic-pressed oils?

Alderks: Most hydraulic mills process to give a low refining loss oil. However, what may apply to one mill may not apply to another 100 miles away. To some extent the refining of hydraulic oils is still an art and one must gain experience in order to obtain optimum results. What you want to do in hydraulic processing is to process at the lowest temperature to give the lowest residual oil content in the meal and the lowest possible refining loss in the oil.

Ward: What is your opinion, Mr. Keller? You operate screw presses utilizing water-cooled jackets.

Keller: The water temperature of the barrel reaches approximately 140° F., and that of the screw approximately 110° F. These are water temperatures, and we are not prepared to say that the cake temperature is the same. There is no doubt but that there is some cake cooling, but the exact extend of this cooling is not known.

Black: In connection with oil quality, there is more and more pressure on the refiner to produce lighter and lighter oils. Your processind conditions will have to be governed to some extent by what will give oils that will bleach to the lightest possible color.

Fincher: We use a slightly different process for refining solvent-extracted oil than that used by Mr. Alderk's company. They probably get lower refining losses. In our experience cottonseed oils having 0.6 to 0.7 percent free fatty acids have refining losses of slightly less than 3 percent. On hydraulic operations this is not the general thing. As a general rule, it is found that expeller cottonseed oils run higher in refining losses. In all probability, this is due to the larger quantities of phospho-lipid material extracted, and I believe that this high concentration of phospho-lipid material is due to the way the material is cooked and the fact that it is dry when pressed. The quality of screw-pressed oils could possibly be improved by doing some work on the cooking operation.

Newby: At the present time we are discussing quality of the oil, which is a little different problem from that of meal quality, but since both are products of the same processing, it is difficult to separate the two. We have been concerned with improving the nutritional quality of the meal, which is very important. However, the quality of the oil may be of greater importance economically, as a great deal of profit from a ton of seed comes from the oil. Some of the conversation at this meeting has seemed to indicate that a general conversion of the cottonseed oil industry to screw-press operation would be desirable. If the screw press operation would yield a better quality oil than that produced by the hydraulic press, such a shift might be desirable. Generally, however, hydraulic-pressed oils are of higher quality. At the present time, in the face of considerable competition by soybean oil, cottonseed oil holds a favorable position in regard to salad oils and some shortenings because of its excellent bleachability. Expeller oil does not, in general, equal hydraulic oil in bleachability. If there is a general conversion to expeller processing, there will be more trouble from this source, and in general the oil will not be of as high quality as oil which is predominantly hydraulic-pressed. If the refining loss is higher this cannot be adjusted by an adjustment in price: but if the bleachability is not there the product cannot be used for the production of a high quality shortening or salad oil. As long as the amount of expeller oil is, as at the present time, only a small portion of the total production, it can be blended with the higher quality hydraulic oil without materially reducing the quality of the product. However, were the extent of the expeller oil to increase,

this would make it easier for other oils to compete with cottonseed oil in the production of these high quality products. These remarks are predicated on the supposition that the quality of the expeller oil will not be improved. Unless the quality of the expeller oil can be improved along with the quality of the meal, a general conversion of the cottonseed oil industry from hydraulic- to screw-press methods would result in a loss rather than a gain.

Ward: I want to make it clear that no one proposes that there be a changeover from one type of processing to another until it has been definitely proven advantageous and economically sound to do so. We know that if we can improve our meals, we can also improve our oils. We may perhaps get a better oil. That remains to be seen. But mills will not change their methods — any more than farmers will change their feeding practices — unless the changes will actually pay them more money.

Williams: I feel sure the oils produced in the experimental runs in our mill were as high in quality and as low in refining loss as those produced by normal practice.

Colter: You spoke of adjusting the pressure in the screw press so as to yield a thiamin value of 12 parts per million -- my question is how much oil will this leave in the meal? As you know, at the present time the price of oil is relatively high and any excess oil left in the meal would be a distinct economic loss.

Altschul: There is a range of operations where, when you increase the pressure, you don't get any more oil. In other words, some mills operate under pressures higher than necessary to get the maximum amount of oil out. Mr. Fincher's company made three meals, varying the conditions of cooking and also the throughput. I don't recall the exact residual oil content but in every case it was equal. Gossypol content also was constant, but the thiamin content varied from 7 to 18 parts per million.

Colter: Then you would not lose the oil from the meal?

Altschul: No, sir.

Lyman: I would be interested in the effect the reduced throughput has on production rate.

Williams: Generally in reducing the temperature of cooking, the meal is in such a form that it does not feed well through the barrel of the press. I believe this can be altered. We experienced no difficulty in attaining an output of 50 pounds of meal in 5 minutes in any of the experimental runs, and I believe the output can be increased once the operating conditions have been established and proper adjustments made.

It is slightly more difficult to operate the expellers at extremely low temperatures, but that difficulty can be overcome with the experience gained in such operation. Once the optimum conditions are determined it should be possible to operate under them satisfactorily.

Kruse: The ease of detoxification merely by shear action in the barrel of the press is an interesting point. Why don't the manufacturers of screw-press equipment make a true prepress for use with solvent extraction operations? Prepressing definitely fits into the economics of cottonseed solvent extraction operations. I believe that properly adjusted prepressing machines would give the shearing action and detoxification necessary for the production of highly nutritive cottonseed meal by solvent extraction.

Terstage: Speaking for the V. D. Anderson Company, I can say that we are interested in securing the best possible results for the processor and will work along with him in developing machinery and procedures pointing towards production of the highest possible quality oil and the best possible meals. In regard to prepressing, the machinery is specially designed to provide the high capacity necessary for the solvent extraction unit. With the Exsolex process, refining losses have been considerably lowered, and oil color has been decreased. This shows that we are on the right track. We hope at a later date to have more complete information. As to our expellers, they operate efficiently when cooking in the range of 190-200° F. Our tests are not finished, but before we are through we expect to have some of the answers for expeller and oil mill operators ingeneral. In regard to refining losses, in some cases we find that expeller oils can be refined the same as hydraulic oils, and others cannot. Since the expellers are standard, the differences lie in processing, and often these conditions are not optimum for the best production of high quality oil and meal. These operations are still mainly an art, and improvement is mainly a matter of eduction. We are undertaking parts of this educational program and once our results are complete, will make them generally available.

Wamble: Temperature is a very important factor. In the hydraulic press operation, one reason why such high temperatures are used is that no further heat is applied and the meats must warm the press so as to more readily yield free-flowing oil. It has been revealed in the industry, and the data are available, that this temperature has a most important influence on extraction efficiency. Of course the screw-press operation is a much faster operation, so high temperatures are necessary for only a very short time as the meal passes rapidly through the expeller barrel. This probably explains why we can produce meals of high nutritive value in the screw press using modest cooking conditions, prior to the expeller.

Ross: The emphasis in nutritional investigations so far has been on swine and poultry, yet a very considerable quantity of cottonseed meal is used to feed ruminants. In the feeding of cattle, cottonseed meal still has a good way to go, since its efficiency is not as high as that of other meals. Where linseed meal is 100, cottonseed meal is in the neighborhood of 70. In wintering trials it appeared that soybean meal was superior to cottonseed meal. Althought it would be a considerable drain on the experimental facilities to produce the large quantities of cottonseed meal required for cattle feeding trials, I feel that it would be well worth while to conduct such a project and determine whether these new, specially-processed cottonseed meals are better for ruminants than those which have been used heretofore — and I throw open to this group the suggestion that perhaps much of the cottonseed meal work on cattle needs to be re-investigated.

Newton: I think we all agree that there is still a lot of work to be done, but we do have a good material to work with. This conference has shown that if we handle cottonseed meal properly, and reinforce it where it has shortcomings, we will be able to produce a feed or food that will compete with any product.

A P P E N D I X

COTTONSEED NUTRITIONISTS AND PROCESSORS CONFERENCE
Southern Regional Research Laboratory
November 13-14, 1950

P R O G R A M

Monday, November 13

Morning Session

CHAIRMAN

H. W. Marston, Research Coordinator, Agricultural Research Administration, U. S. Department of Agriculture, Washington, D. C.

OPENING REMARKS

C. H. Fisher, Director, Southern Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, New Orleans, La.

A. L. Ward, Director, Educational Service, National Cottonseed Products Association, Dallas, Texas

REVIEW OF NUTRITIONAL RESEARCH ON COTTONSEED MEAL

C. M. Lyman, Head, Department of Biochemistry and Nutrition, Texas Agricultural Experiment Station, College Station, Texas

REVIEW OF METHODS OF ANALYSIS OF COTTONSEED MEAL

T. H. Hopper, Head, Analytical and Physical Division, Southern Regional Research Laboratory, New Orleans, La.

THE PIGMENT GLAND-FRACTIONATION PROCESS

E. A. Gastrock, Head, Engineering and Development Division, Southern Regional Research Laboratory, New Orleans, La.

LUNCHEON

Monday, November 13

Afternoon Session

CHAIRMAN

J. R. Mays, Jr., Chairman, Technical Advisory Committee, National Cottonseed Products Association, Memphis, Tenn.

EFFECT OF PROCESSING CONDITIONS ON CHEMICAL PROPERTIES OF COTTONSEED MEAL

F. H. Thurber, In Charge, Products Section, Protein and Carbohydrate Division, Southern Regional Research Laboratory, New Orleans, La.

NUTRITIONAL VALUE AND AMINO ACID AVAILABILITY OF COTTONSEED MEALS. SERIES 1 and 5.

M. J. Horn, Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture, Beltsville, Md.

EFFECT OF PROCESSING VARIABLES ON NUTRITIVE VALUE OF COTTONSEED MEAL FOR POULTRY AND SWINE

N. R. Ellis, H. R. Bird, J. L. Milligan, and J. C. Blight, Bureau of Animal Industry, U. S. Department of Agriculture, Beltsville, Md.

THE EFFECT OF GOSSYPOL ON EGG HATCHABILITY, WEIGHT, AND YOLK COLOR

B. W. Heywang, Southwest Poultry Experiment Station Bureau of Animal Industry, U. S. Department of Agriculture, Glendale, Ariz.

COTTONSEED MEAL TOXICITY STUDIES

K. T. Holley and W. S. Harms, Georgia Agricultural Experiment Station, Experiment, Ga.

STUDIES ON THE VITAMIN B_{12} ACTIVITY OF AND UNIDENTIFIED NUTRIENTS IN COTTONSEED FLOURS AND MEALS

A. M. Hartman and L. P. Dryden, Bureau of Dairy Industry, U. S. Department of Agriculture, Beltsville, Md.
(Abstract read by A. M. Altschul, Southern Regional Research Laboratory)

DISCUSSION

Tuesday, November 14

Morning Session

CHAIRMAN

H. P. Newton, Assistant Director, Southern Regional Research Laboratory, New Orleans, La.

NUTRITIONAL VALUE OF COTTONSEED MEALS IN SERIES 5

J. R. Couch, Texas Agricultural Experiment Station, College Station, Texas

Fred Hale, Texas Agricultural Experiment Station, College Station, Texas (Read by C. M. Lyman)

THE USE OF DETOXIFIED COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR GROWING PIGS

E. L. Stephenson and A. L. Neumann
University of Arkansas, Fayetteville, Ark.

THE USE OF DETOXIFIED COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR LAYING HENS

E. L. Stephenson, University of Arkansas, Fayetteville, Ark.

PRELIMINARY OBSERVATIONS ON SUPPLEMENTING VARIOUS CORN-COTTONSEED MEAL RATIONS

T. J. Cunha, C. B. Shawver, and R. F. Sewell, Department of Animal Husbandry and Nutrition, Florida Agricultural Experiment Station, Gainesville, Fla.

IMPROVING COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR SWINE

E. R. Barrick, Department of Animal Husbandry, North Carolina Agricultural Experiment Station, Raleigh, N. C.

EFFECT OF PROCESSING VARIABLES ON AVAILABILITY OF AMINO ACIDS IN COTTONSEED MEAL

K. A. Kuiken, Texas Agricultural Experiment Station, College Station, Texas

LUNCHEON

Tuesday, November 14

Afternoon Session

CHAIRMAN

G. W. Irving, Jr., Assistant Chief, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Washington, D. C.

FUTURE PROGRAM OF RESEARCH ON COTTONSEED MEAL

A. M. Altschul, Head, Protein and Carbohydrate Division, Southern Regional Research Laboratory, New Orleans, La.

Round Table Discussion

TOUR OF LABORATORY

COTTONSEED NUTRITIONISTS AND PROCESSORS CONFERENCE
Southern Regional Research Laboratory
November 13-14, 1950

LIST OF ATTENDANCE

Industry

Alderks, O. H., Technical Division, The Buckeye Cotton Oil Co., M.A. & R. Bldg., Ivorydale, Cincinnati 17, Ohio.
Black, H. C., Assistant Director of Research, Swift & Co., Union Stock Yards, Chicago 9, Illinois.
Colter, Robert R., Sales Department, Producers Cotton Oil Co., Fresno, Calif.
Ettinger, William, Promotion Manager, J. T. Gibbons Co., New Orleans, Louisiana.
Gandy, Dalton E., Field Representative, Educational Service, National Cottonseed Products Association, Inc., Ruston, Louisiana.
Gregory, T. H., Executive Vice-President, National Cottonseed Products Association, Memphis, Tennessee.
Hardin, S. L., Sales Manager, Hardin Bag & Burlap Co., 1054 Constance St., New Orleans, Louisiana.
Keller, Paul, President, Central Oil & Milling Co., Clayton, N. C.
Kruse, N. F., Tech. Director and Vice-President, Central Soya Co., Inc., Decatur, Indiana.
Landau, Paul, Manager, J. T. Gibbons Co., New Orleans, Louisiana.
Lowe, W. D., President, National Cottonseed Products Assn., Jackson, Miss.
Mays, J. R., Jr., Vice-President, Barrow-Agee Laboratories, Inc., Memphis, Tenn.
Moore, Walter B., Assistant Director, Educational Service, National Cottonseed Products Assn., Inc., 618 Wilson Building, Dallas 1, Texas.
Morgan, Irvin, Jr., President, Morgan Oil & Refining Co., 600 West Pine St., Farmville, N. C.
Roberts, Bob, Manager, Proflo Division, Traders Oil Mill, Fort Worth, Texas.
Rogers, J. Van, Southeastern Representative, Educational Service, National Cottonseed Products Assn., Inc., Atlanta, Georgia.
Sherman, W. C., Manager, Biological Research Labs., Ralston Purina Co., Checkerboard Square, St. Louis 2, Missouri.
Smith, Leonard, Collaborator, National Cotton Council of America, Marsh Bldg., 1832 M. Street, N. W., Washington 6, D. C.
Terstage, Robert J., The V. D. Anderson Co., 1935 West 96th St., Cleveland 2, Ohio
Tierney, M. J., Chemist, Naugatuck Chemical, Naugatuck, Connecticut.
Ward, A. L., Director, Educational Service, National Cottonseed Products Assn., Inc., 618 Wilson Building, Dallas 1, Texas.
Williams, P. A., Chief Chemist, South Texas Cotton Oil Co., Houston, Texas.
Woodruff, Ralph, Manager, Osceola Products Co., Osceola, Arkansas.
Schwartz, A. K., South Texas Cotton Oil Co., Houston, Texas.

State Universities and Experiment Stations

Barrick, E. R., Assoc. Professor, Animal Husbandry Section, Dept. of Animal Industry, Univ. of N. C., State College Station, Raleigh, N. C.
Baumgardner, John H., Asst. Professor, Dept. of Animal Husbandry, Texas Technological College, Lubbock, Texas.
Couch, J. R., Professor, Dept. of Poultry Husbandry, Texas A. & M. College System, College Station, Texas.
Cunha, T. J., Associate Professor, Dept. of Animal Husbandry & Nutrition, University of Florida, Agricultural Experiment Stations, Gainesville, Fla.
Dyer, Irwin A., Asst. Professor, University of Georgia, Athens, Georgia.
Epps, Ernest A., Jr., Chief Chemist, La. Dept. of Agriculture, Baton Rouge, La.
Fletcher, J. Lane, Associate Professor, Animal Husbandry Dept., Miss. State College, School of Agri. & Experiment Station, State College, Mississippi.
Frye, J. B., Jr., Head, Dairy Dept., College of Agriculture, L.S.U., University Station, Baton Rouge 3, La.
Heywang, Burt W., Poultry Husbandman in Charge, Southwest Poultry Experiment Station, U.S.D.A., Route 1, Box 80, Glendale, Arizona.
Holley, K. T., Chemist, Georgia Agricultural Experiment Station, Experiment, Ga.
Kidwell, James F., Professor and Animal Husbandman, Animal Industry Research Dept., Experiment Station, La. State University, Baton Rouge 3, La.
Kuiken, K. A., Asst. Professor, Dept. of Biochemistry in Nutrition, Texas Agricultural Experiment Station, College Station, Texas.
Lovvorn, Henry H., Head, Animal Husbandry Dept., Miss. State College, School of Agri. & Experiment Station, State College, Mississippi.
Lyman, Carl M., Head, Dept. of Biochemistry in Nutrition, Texas Agricultural Experiment Station, College Station, Texas.
Meinke, Wilmon W., Assoc. Res. Chemist, Eng.Expt. Sta. of Texas, 306 Crescent Drive, Bryan, Texas.
Morgan, C. L., Head, Poultry Dept., School of Agriculture, S. C. Experiment Station, The Clemson Agricultural College, Clemson, S. C.
Ross, O. Burr, Professor, Animal Husbandry Dept., Oklahoma A. & M. College, Agricultural Experiment Station, Stillwater, Oklahoma.
Rusoff, L. L., Assoc. Dairy Nutritionist, College of Agriculture, L.S.U., University Station, Baton Rouge 3, La.
Salmon, W. D., Head, Dept. of Animal Husbandry & Nutrition, Alabama Polytechnic Institute, Auburn, Alabama.
Singletary, C. B., Asst. Animal Husbandman, Animal Industry Research Department, Experiment Station, Louisiana State University, Baton Rouge 3, Louisiana.
Stephenson, Edward L., Asst. Professor, Dept. of Animal Industry, University of Arkansas, Fayetteville, Arkansas.
Upp, C. W., Head, Poultry Industry Department, Agricultural Experiment Station, L. S. U., Baton Rouge 3, Louisiana.
Wamble, A. Cecil, Manager, Cottonseed Prods. Res. Con., Texas Eng. Expt. Station, College Station, Texas.
Watts, A.B., Asst.Prof.,Poultry Industry Dept., Agri. Experiment Station, LSU, Baton Rouge, Louisiana.

U. S. Department of Agriculture

Ellis, Nod R., Chemist in Charge, Animal Husbandry Divn., Bureau of Animal Industry, U.S.D.A., Beltsville, Maryland.
Gilliland, C. B., Chief, Research Division, Fats & Oils Branch, Production & Marketing Administration, U.S.D.A., Washington, D. C.
Horn, Millard J., Chemist, Bureau of Human Nutrition & Home Economics, U.S.D.A., Washington, D. C.
Irving, Geo. W., Jr., Assistant Chief, Bureau of Agricultural & Industrial Chemistry, U.S.D.A., Washington, D. C.
Marston, H. W., Research Coordinator, Agricultural Research Administration, U.S.D.A., Washington, D. C.

Other Federal Agencies

Farrell, Kenneth T., Chief, Gen. Products Division, Food Laboratories, QM Food & Container Institute for the Armed Forces, Chicago QM Depot, USA, Chicago 9, Illinois.

S U M M A R Y

(Note: This summary of the conference was furnished on November 17, 1950 to trade and technical journals serving the oilseed industry.)

An improved cottonseed meal of high nutritive value produced experimentally by modification of ordinary screw-pressing methods has been tested with favorable results in the diets of hogs and chickens, according to reports heard at a conference of cottonseed nutritionists and processors held at the Southern Regional Research Laboratory, New Orleans, La., November 13-14, 1950.

In his welcome address, Dr. C. H. Fisher, Director of the Laboratory, said this development brings cottonseed meal utilization to the threshhold of a new era. The improved product promises greatly enlarged outlets for the South's principal oilseed crop, he explained.

Fifty-five persons from 20 states and Washington, D. C., attended the conference. Officials of the National Cottonseed Products Association, the cottonseed processing industry, State Experiment Stations, and the U. S. Department of Agriculture, actively participated. Feed manufacturers, machinery companies, the soybean industry, and State Feed Control Boards also were represented. Besides evaluating recent cooperative studies, which have shown that screw-pressing conditions can be adjusted to produce cottonseed meal of improved quality and digestibility, the group freely discussed additional research needs.

H. W. Marston, Agricultural Research Administration Coordinator, presided at the opening session. J. R. Mays, Jr., Chairman, Technical Advisory Committee, National Cottonseed Products Association, led the afternoon session November 13. Presiding officers on November 14 were Harry P. Newton, the Laboratory's Assistant Director, and George W. Irving, Jr., Assistant Chief, Bureau of Agricultural and Industrial Chemistry.

In an opening talk, A. L. Ward, Director of the National Cottonseed Products Association's Educational Service, called the new-type cottonseed meal an outstanding example of what can be accomplished through teamwork. The Southern Regional Research Laboratory, working in cooperation with the South Texas Cotton Oil Company, developed the method for producing the meal. It is based on information obtained during several years of fundamental research at the Laboratory. Other USDA agencies and State Experiment Stations have conducted extensive feeding trials to establish the nutritive value of the improved product. The NCPA has cooperated actively in bringing the development to the attention of oil mill operators, a number of whom are now applying the technique experimentally to determine its application in different localities.

The results of feeding cottonseed meals, produced by different methods, in a variety of Experiment Station tests were reviewed by C. M. Lyman, J.K. Couch, and K. A. Kuiken for Texas; E. L. Stephenson for Arkansas; T. J. Cunha for Florida; K. T. Holley for Georgia; and E. R. Barrick for North Carolina. M. J. Horn, Bureau of Human Nutrition and Home Economics, with N. R. Ellis and B. W. Heywang, of the Bureau of Animal Industry, contributed the findings of Department of Agriculture nutritionists.

Both poultry and hogs thrived on diets in which the improved meal was used freely as the protein supplement. The animals maintained good appearance and excellent growth rates throughout the experiments.

F. H. Thurber, of the Southern Laboratory staff, described the processing conditions used in producing the new experimental meals supplied for these tests. Mild conditions of cooking (below 200 degrees F.) and mild screw-press operations must be carefully maintained to avoid destruction of the protein value, he explained.

T. H. Hopper reviewed the Laboratory's methods for cottonseed meal analysis, and E. A. Gastrock described the pilot-plant development of a process for deglanding cottonseed meal.

A. M. Altschul outlined problems at which future research should be directed. Now that tentative specifications for producing improved cottonseed meal can be suggested, one of the next steps is to establish the limits of usefulness of the new product for all types of feed, he said.

The Southern Regional Research Laboratory will spear-head further cooperative efforts to apply the principles learned in research on screw-pressing to improve the quality of cottonseed meals produced by hydraulic-pressing and solvent-extraction; to compare the quality and yield of cottonseed oils produced by the modified techniques with oils obtained with ordinary crushing methods; to determine production rates and evaluate the overall economic problems involved in adopting the new techniques, Dr. Altschul added.

DESCRIPTION OF COTTONSEED MEALS IN NUTRITION PROCESSING TEST, SERIES 1.

Meal No.	Water added to cooker lb./hr.5/	Temp. of meats, °F.	Time of cooking, min.	Meal: Lipids % 6/	Meal: Free gossypol % 6/	Meal: Moisture % 6/	Meal: Total nitrogen % 6/	Meal: Soluble 7/ nitrogen % of total
			Hydraulic-pressed Meals 1/					
2	70	118-230	36	5.6	0.108	7.6	6.4	39.2
9	90	118-240	72	5.6	0.047	5.6	6.4	20.8
			Screw-pressed Meal 2/					
7 4/	None	100-200	70	3.4	0.008	4.7	6.4	12.8
8 4/	None	110-178	15-20	3.3	0.011	4.6	6.9	14.3
6 4/	None	100-200	15-20	3.4	0.009	4.1	6.5	15.9
1	None	113-234	15-20	3.5	0.014	4.6	6.9	11.7
3	None	126-261	20	3.6	0.016	4.4	7.0	10.0
4 3/	60	202-262	40	3.8	0.022	4.5	7.0	10.3
5 3/	70	222-278	100	5.7	0.030	3.7	6.6	8.2

1/ From rolled meats: water added before rolls for hydraulic runs was 60 lbs./hr.

2/ From disc hulled meats.

3/ Four rings of cooker used. In all other runs involving screw press, only three rings were heated.

4/ In order to obtain these low temperatures, doors of cooker rings were kept open.

5/ Meal production on the screw press was at the rate of 600 lbs./hr.

6/ On as received basis.

7/ Determined in 0.5 N NaCl solution at a solvent-meal ratio of 40:1.

DESCRIPTION OF COTTONSEED MEALS IN NUTRITION PROCESSING TEST, SERIES 5

Run No.	Cooking Conditions		Press Conditions		MEAL			
	Time	Maximum temperature	Energy input	Cake in 5 minutes	Lipids*	Free Gossypol Like Material*	Soluble Nitrogen	Thiamin micrograms/gm (ppm)
	min.	°F.	Amperes	lbs.	%	%	%	
1	37	230	60	60	3.70	0.0278	15.3	7.8
2	36	230	55	60	4.48	0.034	23.7	10.7
3	35	230	50-52	60	4.41	0.0365	30.6	11.1
4	31	230	60	50	3.80	0.0259	16.9	9.1
5	22	200	50-51	50	4.57	0.0363	37.9	13.4
6	22-26	200	55	50	4.32	0.0302	37.2	13.2
7	22-26	201	55-58	50	3.97	0.0302	30.0	14.2
9	22-26	180	55	50	4.14	0.019	31.7	13.0
10	22-26	180	50	50	4.14	0.0437	41.4	15.1
12	22-26	180	60	50	4.11	0.0343	23.0	12.7
13	22-26	200	60	50	4.05	0.028	26.5	12.3
14	22-26	200	50	50	4.70	0.0459	42.2	13.2
16	38	160	58	50	3.78	0.0203	35.0	11.5
16B	36	160	58-60	50	4.00	0.023	34.6	13.8
17	33	185	57	50	4.83	0.0449	45.0	12.8

* Dry Basis